United States
Department of
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Appraisal 1980

Soil and Water Resources
Conservation Act

Review Draft
Part II

SOIL AND WATER RESOURCES CONSERVATION ACT

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UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

Congress passed the Soil and Water Resources Conservation Act (RCA) in 1977. This Act directs the Secretary of Agriculture to conduct a continuing appraisal of the status and condition of our soil, water, and related resources. The Department of Agriculture has prepared the first appraisal in two parts. In August 1979, the Department published Part I of the 1980 Appraisal. This report is Part II. Part I provides information on the quantity and quality of soil and water resources, land capability, dominant soil conditions, and major uses of nonfederal land. It also contains an inventory of legislation and regulations dealing with resources and discusses impact of historical and institutional factors and technology on conservation, and public concerns regarding conservation problems.

Part II considers various levels of future demands in seven potential problem areas--soil resources, water quality, water supply and conservation, fish and wildlife habitat, upstream flood damages, energy conservation and production, and related natural resources. It also describes the assumptions that underlie projections of future demands and conditions, the analytical methods used in the forecasting, and the process used to develop the RCA Appraisal, Program, and Environmental Impact Statement.

Part II also reviews strategies that could be used to develop the Department of Agriculture's future soil and water conservation programs. In addition, it identifies federal, state, and local contributions to soil and water conservation programs, and reviews landownership trends and other socioeconomic data relating to conservation.

Related concerns such as recreation, air quality, and rare and endangered species are not discussed definitively in the 1980 RCA Appraisal. These and related concerns will be addressed in greater detail in the 1985 reports.

The Department of Agriculture is using the 1980 Appraisal as a basis for evaluating its soil and water conservation programs and policies. This evaluation will enable USDA to institute better management and planning that will help the Nation maintain and improve its natural resources. The Department will prepare the next appraisal in 1985.

SUMMARY

Congress passed the Soil and Water Resources Conservation Act (RCA) in 1977. That Act directs the Secretary of Agriculture to conduct a continuing appraisal of the status and condition of our soil, water, and related resources. The Department of Agriculture has prepared the first appraisal in two parts. In August 1979, the Department published Part I of the 1980 Appraisal. This report is Part II. Part I provides information on the quantity and quality of soil and water resources, land capability, present soil conditions, and major uses of nonfederal land. It also contains an inventory of legislation and regulations dealing with resources and discusses impact of historical and institutional factors and technology on conservation, and public concerns regarding conservation problems.

Part II considers existing conditions and trends in seven potential problem areas--soil erosion, water quality, water supply and conservation, fish and wildlife habitat, upstream flood damages, energy conservation and production, and related natural resources. It also describes the assumptions that underlie projections of future demands and conditions, the analytical methods used in the appraisal, and the process used to develop the RCA Appraisal, Program, and Environmental Impact Statement.

Part II also reviews strategies that could be used to develop the Department of Agriculture's future soil and water conservation programs. In addition, it identifies federal, state, and local organizations in soil and water conservation programs, and analyzes landownership trends and other socioeconomic data relating to conservation.

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Appendix

Chapter 1 - Summary and Highlights

The Nation's soil and water resources are subject to increasing pressure to produce more food and fiber, to provide more opportunities for recreation, and to accommodate urban growth. Congress, concerned that abuse or overuse of soil and water could deprive future generations of the resources that they will need to maintain an adequate standard of living, enacted the Soil and Water Resources Conservation Act of 1977 (RCA). This Act directs the Secretary of Agriculture to continuously appraise the condition of and trends in the Nation's soil and water and to develop an appropriate program to maintain or improve the condition of these resources.

Before the Department of Agriculture could develop a new program, it had first to determine the most serious resource problems that the Nation faces today and is likely to face in the next 50 years. To do this, USDA made certain assumptions and projections concerning population, prices, technology, agricultural exports, and other factors that affect the demand for and the supply of food, fiber, outdoor recreation, water, and land. It took into account environmental concerns and the availability of water and energy. Chapter 2 outlines the basic assumptions and projections that USDA used in analyzing problems and developing soil and water conservation objectives, activities, and program strategies.

Chapter 2 also contains three scenarios of the future. Each scenario assumes a constant, moderate growth in population and agricultural technology. The only difference among these scenarios is the level of agricultural exports. One scenario assumes no exports, the second assumes that exports will remain at 1975-77 levels, and the third assumes a moderate growth in exports. USDA used these scenarios in projecting future demands for the products of renewable resources and in projecting the future condition of the resources themselves.

Using these assumptions and projections, the Department studied potential problem areas related to resource use. For each potential problem area, USDA determined the scope of the problem, the aspects of the problem requiring attention, and the alternative levels of improvement that could be attained given various levels of support to address the problem. Chapter 3 shows how the Department identified these areas, presents analyses of the problems, offers alternative objective levels, and identifies needs for future analysis.

Although these problem areas are interrelated, USDA considered each one separately in order to determine as precisely as possible the extent of the problem and reasonable expectations for improvement. The seven potential problem areas are:

- Soil resources.--The growing population and the increasing demand for agricultural products for domestic consumption and export may strain agriculture's ability to increase production over the next 50 years. The damage to the Nation's soil could be extensive. The challenge facing American agriculture during this period will be to decrease erosion, cultivate potential farmlands but not those better suited to other uses, and increase technology.

In many parts of the Nation, the soil is eroding at rates that could--if all other factors remain unchanged--reduce productivity by one-fifth in the next 50 years. Unless this erosion is checked, millions of acres of land not now farmed may need to be cultivated. In addition, millions more acres would be needed to keep abreast of projected increases in demand. Although the condition of rangeland and native pasture is generally improving, it is far below its potential.

Future crops could be grown on the millions of acres of land that are not now farmed but that could economically be cultivated. Converting these lands to cropland may involve some costs, however, because rangeland, woodland, and wetlands would be lost. Also, if erodible land is farmed, such problems as erosion and sedimentation can negate the benefit of the extra food produced.

- Water quality.--Water pollution affects to some degree 95 percent of the Nation's drainage basins. Bacteria, oxygen depletion, nutrients, and toxics are the most common pollutants. These pollutants are discharged directly into rivers, lakes, and streams in concentrated loads from manufacturing plants, sewage treatment facilities, and open sewers. They are carried over the land in runoff until they enter ground or surface water. Although these problems are naturally more severe where populations are high and industrialization is intense, they are serious in many rural areas as well. Runoff from cropland, woodland, and formerly mined land discharges pollutants into streams in many areas.

- Water supply and conservation.--Problems with water supply are not confined to those dry areas in the West that most people associate with water shortages. Periodic or local water supply problems affect almost all areas of the Nation. And while many people consider water supply only in terms of irrigation, domestic consumption, or other uses that require withdrawal of water from streams, lakes, or aquifers, water supply also means maintaining streamflow, which is essential for fisheries, recreation, and other uses.

  Irrigation of agricultural lands requires more water than any other single use of water. Irrigation efficiency could be markedly improved, and the water thus saved could be allowed to remain in the channel to augment streamflow.

  In many areas, demand for water exceeds local supplies. In those places, water must be brought in from other areas or ground water supplies must be tapped. Where ground water is withdrawn faster than it is recharged, water problems may be severe.

- Fish and wildlife habitat.--Wildlife generally thrive where vegetation is varied. Under such conditions, wildlife can find ample food and adequate shelter. As agriculture becomes more intensive, conditions of optimum diversity become more scarce; monoculture, specialization, and drainage have drastically reduced wildlife populations in many areas. Despite this, even where lands are farmed intensively, good farm management can improve the quality of the existing habitat. Furthermore, land set aside specifically for wildlife can in many places exist side by side with farmland.

Fish habitat is largely dependent on water quality. The freer the water is from toxics, sediment, and other pollutants, the better the habitat will be for fish. Better management of farmland may significantly improve water quality by reducing erosion and runoff. Additionally, since many farm ponds are managed to produce fish, better management of these ponds could significantly increase the annual catch.

- Upstream flood damages.--Flood damages to farmland, woodland, and towns and cities in upstream areas average more than $1 billion per year. Without efforts to control such damage, USDA estimates that annual flood damages will rise by almost 50 percent over the next 20 years. The simplest way to minimize flood damages is to use flood plains wisely. Unfortunately, these areas are among the most attractive for urban developments, intensive farming, and other incompatible uses--until floods wipe them out.

- Energy conservation and production.--The Department of Agriculture has announced a goal of energy self-sufficiency on farms and ranches by 1990. This means that the total amount of energy produced on farms and ranches will be equal to or will exceed the amount used there. It does not, however, necessarily mean that any single farm will produce all of the energy it uses.

  USDA sees a number of ways in which improved or different management could significantly reduce energy use on farms: (1) more extensive use of conservation tillage, (2) improved crop drying techniques, (3) more efficient use of fertilizer, (4) conservation management to reduce soil erosion, (5) retention of prime farmland for agricultural uses, (6) better management of irrigation water, (7) better management of pasture and range, and (8) more extensive use of shelterbelts and windbreaks. The Department also sees various ways to generate energy on farms: (1) substitute, where possible, organic wastes for chemical fertilizers in order to divert the energy used in producing that fertilizer to other uses, (2) grow crops specifically as a fuel for generating energy, (3) use existing small dams and windmills to generate electricity and pump water, where possible, (4) grow legumes specifically to plow under for the next crop, thereby reducing or eliminating the need for extra fertilizer, and (5) use animal manures to produce methane gas.

- Related natural resources.--Organic waste management, recreation, and soil and water resource management in urban and urbanizing areas are also problems that USDA's new soil and water conservation program should address.

  Many organic wastes that are now being buried or burned could safely be spread over the soil to help improve soil tilth and fertility. Such wastes include manures, sewage sludges, septage, municipal refuse, food processing wastes, and wood manufacturing residues.

  Demands for land- and water-based recreational opportunities will continue to grow. Cooperation between the public and private sectors will be needed if these demands are to be met.

Most urban and urbanizing areas are subject in some degree to problems caused by misuse or poor use of resources. Many urban areas are built on unstable or wet soils, on flood plains, or in wetlands. Additionally, the lack of adequate measures to control erosion around construction sites creates extremely serious sedimentation problems. In many rapidly growing areas, urban expansion competes directly with agriculture for much of the very best farmland. Urban expansion is engulfing about 1 million acres of this prime farmland annually. This loss is irretrievable.

Knowledge about who owns the land and how it is operated is essential in developing and implementing resource conservation programs on private lands. The perceptions of landowners and land users can affect their awareness of the need for conservation and their ability to implement conservation measures. Chapter 4 shows who owns the Nation's private land and the arrangements under which this land is operated.

Seven USDA agencies now administer 34 programs dealing with soil and water conservation. These agencies conduct programs that inventory resources; inform the public about soil and water conservation; identify and locate individual problems; research, plan, and design solutions; and establish programs for action. USDA programs provide cost sharing, loans, and onsite technical assistance in planning and implementing conservation measures. Furthermore, state and local governments are demonstrating increasing interest in conserving soil and water. Chapter 5 discusses federal, state, and local assistance to conservation programs.

To the degree that the Department can predict the future, resource problems can be forestalled. Using its assumptions about and projections of future conditions, its analyses of the seven potential problem areas, its knowledge about trends in landownership, and its experience with existing soil and water conservation programs, the Department has set about developing a new program. Chapter 6 describes possible components for a comprehensive program to achieve proposed soil and water conservation objectives.

USDA considered three alternative organizational structures for delivering a soil and water conservation program. First, the Department could fine-tune the existing system. All agencies would retain their present missions and responsibilities. Procedures would be established to set common goals and reduce duplication. Second, USDA could reassign responsibilities among its agencies in order to simplify delivery. For example, responsibility for all technical assistance for soil and water conservation could be assigned to the Soil Conservation Service, responsibility for all soil and water conservation loan services, to the Farmers Home Administration, and responsibility for all grants, contracting, and cost-sharing services, to the Agricultural Conservation and Stabilization Service. Third, USDA could create a new Soil and Water Conservation Agency and assign to it responsibility for all soil and water conservation activities concerned with nonfederal land. These activities are now divided among the Agricultural Stabilization and Conservation Service, the Economics, Statistics, and Cooperatives Service, the Farmers Home Administration, the Forest Service, the Soil Conservation Service, and the Science and Education Administration. In addition to changes in structure within USDA, possible changes in USDA's relationships with other levels of government were considered. The states could be given a greater role in

planning and directing conservation programs. A multicounty regional approach could be implemented.

USDA considered service delivery mechanisms and program delivery mechanisms that could be used to implement its program. Service delivery mechanisms provide technical information and services. Questions that were considered related to the appropriate combinations of federal, local, and private funding and personnel. Existing programs use various arrangements.

Program delivery mechanisms are designed to implement a soil and water conservation program by offering incentives for compliance and imposing penalties for noncompliance. The mechanisms considered were contracting; linking eligibility for other programs of the Department with adherence to a standard of conservation management; loans, cost sharing, grants, insurance, and other incentives; taxation; and regulation.

In developing the 1980 RCA reports, USDA tapped hundreds of sources. The Department will continue to build on the data it has already collected for use in its continuing evaluation of the status of and trends in soil and water resources. Chapter 7 documents the sources of the data used in the 1980 Appraisal. It also describes the computer models and other techniques used in compiling and evaluating these data.

Chapter 2 - Assumptions and Projections

This chapter presents the basic assumptions and projections the U.S. Department of Agriculture used in developing and evaluating programs for the 1980 RCA reports. USDA made specific projections for the period 1980 through 2030. In making its assumptions and projections, the Department recognized the difficulty in accurately predicting population, community growth, and the demand for or supply of the products of renewable resources. The assumptions are based on past trends, knowledge about developments that may affect the future, and reasonable expectations about future changes.

Historical trends are the result of major social, political, technological, and institutional forces that do not change easily or quickly. Barring a major catastrophe, recent trends are likely to persist into the future and to govern the demands on land, water, and related resources. Therefore, the assumptions and projections in the 1980 reports are extrapolations of recent trends.

Population

Population changes greatly affect the demand for food and fiber, outdoor recreation, and water. They also influence the characteristics of the labor force, which are major determinants of economic activity and materials usage.

Between the late 1920's and the late 1970's, the population of the United States increased by about 100 million people, rising at an average annual rate of 1.7 percent. However, the annual rate of growth declined to about 1 percent in the 1960's and early 1970's and went down to 0.7 percent in 1976 (U.S. Dept. Commerce, 1977). This decline reflects the reduced birth rates that occurred after the "baby boom" of the late 1940's and early 1950's.

Immigration accounts for a significant part of population growth, and the projections used in this appraisal include a net addition of 400,000 legal immigrants each year. There has been some decline in legal immigration recently. Total immigration is unknown, however, because of the unreliable information about illegal immigration.

The distribution of the population has a strong influence on state and regional demands for renewable resources, particularly those that must be produced and consumed in the same place. The Water Resources Council has prepared projections that show significant differences in population trends among the states and regions (USWRC, 1974). The most rapid growth will probably be in the South and on the Pacific Coast. The major population concentrations, however, will remain in the East and North-Central Regions and along the Atlantic and Pacific Coasts.

For RCA analyses, USDA used the Series II population projection made by the Department of Commerce (1977). See table 2-1. This series reflects a continuation of current population trends.

Table 2-1.--Population projected to 2030

Year	Series I 1/	Series II 2/	Series III 3/
	(Millions of people)		
1976	215.2	215.2	215.2
2000	282.8	260.4	245.9
2020	354.1	290.1	253.0
2030	392.8	300.3	249.3

1/ Series I. Annual growth rate ranges from 1.0 to 1.3 percent.
2/ Series II. Growth rate increases to 0.9 percent in the 1980's, then declines to 0.6 percent by 2000 and to 0.3 percent by 2030.
3/ Series III. Annual growth rate drops to 0.3 percent by 2000. By 2030, there will be a slight decline in population.

Demand for Agricultural Products

RCA projections of the demand for agricultural products are based on the 1979 OBERS Program Report (U.S. Dept. Commerce, 1979). The OBERS series projects economic activity for the Nation, individual states, and economic and hydrologic areas. It includes projections of population, personal income, employment, and earnings by individuals and industry. The agricultural projections include agricultural land use and commodity production and value.

The OBERS series is a major product of a program of economic measurement, analysis, and projection conducted by the Bureau of Economic Analysis (BEA), formerly the Office of Business Economics (OBE) of the U.S. Department of Commerce, and the Economics, Statistics, and Cooperatives Service (ESCS), formerly the Economics Research Service (ERS) of the U.S. Department of Agriculture. The program acquired the acronym of "OBERS," signifying a unified effort by OBE and ERS.

The agricultural part of the 1979 OBERS projections relies on the judgment of agriculturalists, economists, and international trade specialists on current and future conditions that affect domestic consumption patterns and agricultural exports.

RCA projections of domestic demand use the consumption patterns shown in the 1978 baseline projections in the National Interregional Agricultural Projections (NIRAP)--a modeling system used by ESCS. The projections of domestic demand are based on the primary factors that influence per capita consumption--disposable personal income, tastes and preferences, and relative commodity prices.

As disposable personal income increases, the demand for some commodities increases and the demand for others decreases. As consumer incomes increase, the demand for beef and veal, chicken, turkey, fruits, and vegetables tends to increase and the demand for eggs, milk, dry beans and peas, and cereal products tends to decrease. ESCS projected per capita consumption of each

commodity at constant prices. It then adjusted the consumption projections for implicit price relationships that reflect export demand as well as domestic consumption. ESCS also included adjustments to reflect increased commodity supplies over time.

Tastes and preferences also influence domestic consumption. As individuals become more concerned with cholesterol levels, they reduce their consumption of eggs, milk products, and high fat meats in favor of lean meats, fruits, and vegetables.

Price differences between commodities tend to shift consumption from one commodity to another in the short run, and in the long run if fundamental changes occur in supply or demand, or both. For example, increased feeding efficiency, improved breeding, and disease control in broiler and turkey production have made poultry much more competitive with beef and veal.

Table 2-2 shows projections of per capita consumption of selected commodities. Per capita consumption of beef and veal has fluctuated with the beef cycle, but has had a strong upward trend since 1950. The projected demand for beef has a much slower upward trend than history would suggest. Per capita consumption of pork has held steady. Consumption of chicken and turkey per capita is projected to increase; consumption of eggs and milk, to decrease.

Table 2-2.--Projections of per capita consumption of selected commodities

Commodity	1975-77 average	2000	2030
		(Pounds)	
Wheat	153	158	173
Rice	10.5	14.2	15.3
Corn	83	126	140
Peanuts	8.6	11.0	11.4
Cotton	16.1	14.0	13.4
Sugar	100	95	94
Citrus fruit	116	139	145
Noncitrus fruit	102	109	115
Vegetables and melons	246	273	290
Irish potatoes	120	134	140
Dry beans and peas	6.6	5.3	4.3
Beef and veal	129	140	152
Pork	59	70	74
Lamb	1.9	1.4	1.2
Chicken	43	65	58
Turkey	9.0	11.7	13.9
Eggs	36	33	30
Milk	549	529	493

Income elasticities (see glossary) are used in projecting per capita consumption of commodities. Income elasticity is a measure of the percentage of change in consumption of a given commodity that results from a 1 percent change in disposable personal income. For example, the income elasticity of beef and veal is 0.66. Therefore, a 1 percent increase in income will increase per capita consumption of beef and veal by 0.66 percent. It is generally assumed that per capita food demand will not increase as rapidly as disposable personal income; therefore, the income elasticity will decrease. Table 2-3 shows the income elasticities of selected commodities. These elasticities are measured on the basis of farm level prices, not retail level prices. Meats are measured using carcass weight rather than live weight.

Table 2-3.--Income elasticities at the farm level for selected commodities

Commodity	Base elasticity	Adjusted elasticity 2000	Adjusted elasticity 2030
Beef and veal (carcass wt)	0.66	0.64	0.63
Pork (carcass wt)	0.09	0.11	0.13
Lamb and mutton (carcass wt)	-1.15	-1.21	-1.16
Chicken (retail wt)	1.26	1.26	1.23
Turkey (retail wt)	1.10	1.11	1.12
Milk	-0.53	-0.50	-0.45
Eggs	-0.44	-0.42	-0.40
Wheat	-0.33	-0.29	-0.26
Rye	-0.20	-0.19	-0.15
Rice	0.70	0.68	0.65
Corn	0.92	0.92	0.89
Oats	-0.05	-0.04	-0.03
Barley	0.59	0.57	0.56
Peanuts	0.80	0.78	0.75
Irish potatoes	0.24	0.24	0.24
Sweet potatoes	-1.64	-1.46	-1.35
Dry beans	-0.50	-0.46	-0.42
Dry peas	-1.45	-1.33	-1.23
Noncitrus fruit	-0.31	-0.26	-0.22
Citrus fruit	0.40	0.41	0.41
Sugar	0.11	0.12	0.14
Vegetables and melons	0.14	0.14	0.15

Total pounds of food (retail weight) consumed per capita has tended to remain relatively steady. This total has varied from a high of 1,651 pounds in 1945 to a low of 1,397 in 1965. Some year-to-year variations have been as high as 68 pounds. Per capita consumption in this analysis is based on farm level commodity weights, except for meats, which are measured by carcass weights. Total food consumption (farm weight) has been increasing since 1966, except in 1973 and 1975. See figures 2-1 and 2-2.

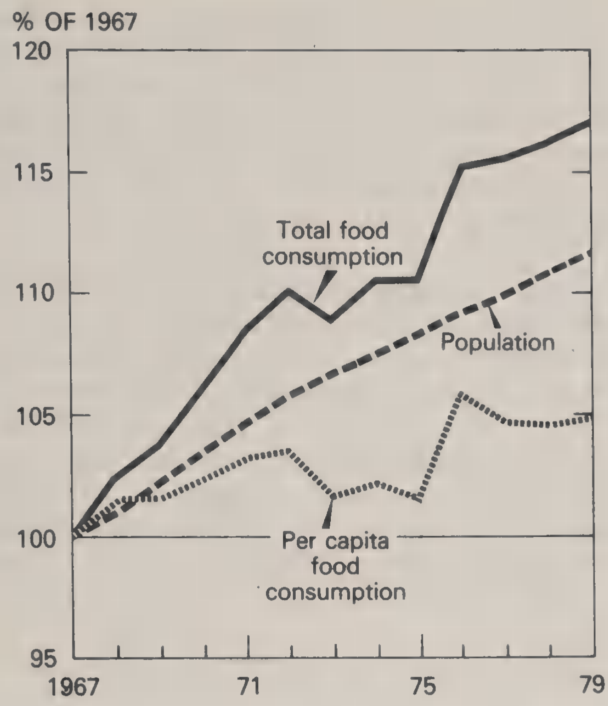


Figure 2-1.--Index of population and food consumption. (Total food consumption based on retail weight using constant retail prices as index weights. Civilian population on July 1, in 50 states.) (USDA. 1979. Agric. Handb. No. 561)

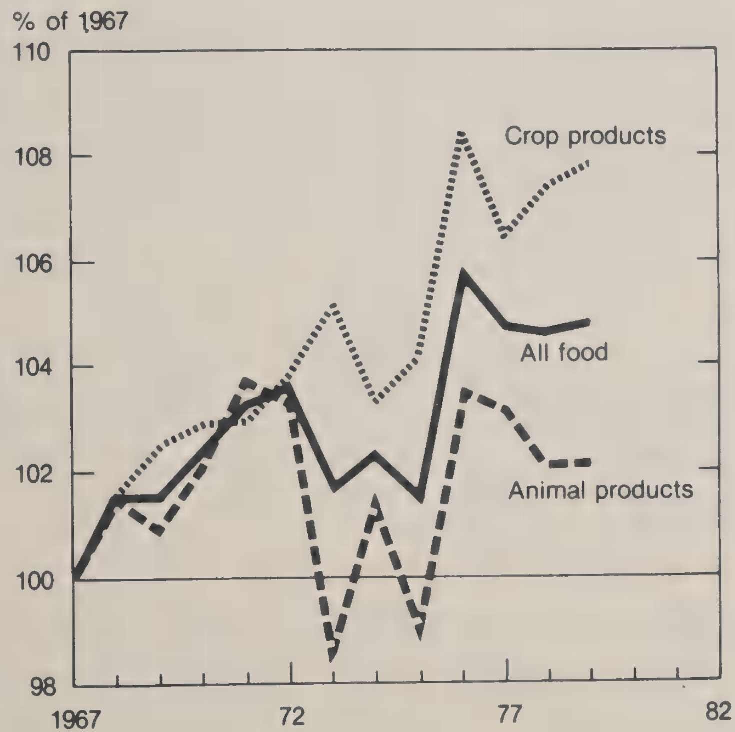


Figure 2-2.--Index of per capita food consumption. (USDA. 1979. Agric. Handb. No. 561)

The projections of export demand assume a 2.3 percent annual increase in exports until the year 2000 and a 0.6 percent annual increase from 2000 to 2030. The growth rate from 1976 to 2000 reflects a continued expansion of international markets for feed grains to meet the needs of expanding livestock industries in developed countries. It also reflects a growth in demand for food grain in developing countries, the USSR, and China as these countries seek to upgrade their populations' diets.

The slower growth rate in exports from 2000 to 2030 results from the higher production costs that will be encountered in meeting expanding export markets. These high commodity prices, in turn, will dampen the international demand for American agricultural exports. The export projections are considered "moderate." They are based on the assumption that countries will continue their existing import policies in an attempt to improve the quantity and quality of their people's diet. Changes in the food production and import policies of importing countries could significantly affect the level of projected American agricultural exports and, correspondingly, American resources. See table 2-4.

Table 2-4.--Projections of exports of selected commodities

Commodity 1/	1975-77 average	2000	2030
Wheat----------------------	1,082	1,999	2,411
Rice-----------------------	65	188	208
Soybeans-------------------	606	1,436	1,866
Corn-----------------------	1,748	2,520	3,229
Sorghum--------------------	233	322	413
Oats-----------------------	12	21	26
Barley---------------------	49	79	101
Export index (1967 = 100)--	169	290	351
Annual growth rate, in percentages:			
1976 to 2000----------	----	2.3	----
2000 to 2030----------	----	----	0.6

1/ All measurements are in millions of units. Rice is expressed in hundredweight. All other commodities are expressed in bushels.

Alternative Scenarios Used in RCA Analyses

USDA is using three scenarios--each based on a different level of exports--to analyze long-range plans for soil and water conservation. See table 2-5. One depicts a level of agricultural production high enough to meet domestic consumption demand only--no exports. The second illustrates resource use and conservation problems associated with a level of production sufficient to supply projected domestic consumption and to maintain current (1975-77) export levels. The third scenario portrays resource conservation problems associated with a level of agricultural production sufficient to meet domestic demand and to sustain a projected moderate growth in exports.

Table 2-5.--Scenarios of the future used in the RCA analyses

	Population 1/	Exports	Technology 2/
Domestic consumption only----	Series II	Zero	Moderate
Domestic consumption plus base exports---------------	Series II	Constant (1975-77)	Moderate
Domestic consumption plus projected exports----------	Series II	Moderate 3/	Moderate

1/ The population growth rate will increase to 0.9 percent in the 1980's and decline to 0.6 percent by 2000 and to 0.3 percent by 2030.

2/ Agricultural productivity will increase by 1.1 percent per year to 2000 and by 0.8 percent annually from 2000 to 2030.

3/ Exports will increase by 2.3 percent annually to 2000 and by 0.6 percent annually from 2000 to 2030.

For each scenario, USDA made detailed analyses on resource use for the years 2000 and 2030. The analyses evaluated how conservation programs could achieve specified levels of reduction in soil erosion. Analyses were made to determine how land use and soil conservation practices can reduce soil losses up to 60 percent under the different export levels assumed in each scenario. The basic scenarios assume that farmers select their crops and production practices to achieve the lowest cost of production and the highest annual net income.

Agricultural Prices

Projecting agricultural prices is difficult because of the wide year-to-year fluctuations in weather and other factors. Each year the Water Resources Council publishes a list of current normalized prices (see glossary) that federal agencies use in evaluating water resource projects (USWRC, 1978a). The agencies use these prices as the approximate long term equilibrium price levels in determining benefit-cost ratios. For RCA, USDA used normalized prices to estimate the gross value of agricultural production. However, to

evaluate the economic consequences of alternative conservation programs, it estimated commodity prices to reflect the cost of producing the last (and most expensive) unit of output demanded by the market. USDA also estimated sets of these "marginal" commodity prices for each program scenario.

Gross National Product (GNP)

In recent decades, changes in the consumption of many resource products have been closely associated with changes in the Nation's GNP. Between 1940 and 1975, the GNP, measured in constant 1972 dollars, increased more than five times--rising at an average annual rate of about 4.7 percent. Annual changes have fluctuated widely, from +16.1 percent to -14.8 percent.

The wide fluctuations in annual growth rates in the GNP reflect such factors as differences in the rates of change in the size of the labor force, unemployment, hours worked per year, and productivity. These factors will continue to cause fluctuations in the GNP. The Water Resources Council's projections indicate that the proportion of the GNP originating in manufacturing and construction will decline slowly over the projection period (1980-2030) (USWRC, 1974).

Transportation, trade, and other services account for a slowly growing share of the total. These changes are consistent with long-established trends. However, the United States will continue to produce huge quantities of physical goods, which means that large supplies of energy, minerals, and other raw materials will be needed. USDA used the Bureau of Economic Analysis projections of GNP for RCA analyses.

Disposable Personal Income

Disposable personal income--the income available for spending or saving--is an important determinant of demand. Since 1929, disposable personal income has equaled about 70 percent of the GNP. USDA assumes that this fairly constant relationship will continue through the projection period. See table 2-6.

Table 2-6.--Economic indicators projected to 2030

Economic indicator	1975-77 average	2000	2030
Per capita disposable income (1972 dollars)-----------------	$4,148	$7,640	$13,779
Percentage of disposable income spent on food-----------------	16.8	17.5	17.5
Export index (1967 = 100)--------	169	290	351
Agricultural productivity index (1967 = 100)------------------	116	147	187

Technological Growth

Technological improvements have enabled American farmers to respond to expanding domestic and foreign demand for agricultural products. Over the past 50 years, agricultural productivity has grown at the rate of 1.6 percent per year. The increase in productivity was about 2.1 percent annually between 1939 and 1965, but the rate of growth has recently declined to about 1.7 percent annually. Lu and Quance (1979) predict that without significant technological breakthroughs, the rate of growth in productivity will continue to decline. The agricultural productivity growth curve under the "science power" era is now entering the stages of declining growth rates. See figure 2-3.

Public expenditures for research and extension increased at a real rate of about 3 percent per year from 1929 to 1972. During the last decade, the growth in federal funding for research and extension declined to about 1 percent per year. State funding increased during this period, however, so federal-state combined spending for research and extension is now growing at about 2 percent per year.

For RCA analyses, USDA assumed that public expenditures for research and extension would continue to grow at a real rate of 3 percent annually (the rate of growth from 1929 to 1972). Under this level of investment, agricultural productivity would slow to 1.1 percent per year between 1980 and 2000 and to 0.8 percent per year between 2000 and 2030.

Technological growth is one of the main factors influencing the capacity of American agriculture. It can have a major impact on (1) the intensity of production methods that farmers use and (2) the corresponding need for conservation practices to maintain soil productivity and minimize environmental damage. USDA will make additional analyses during the public review period to determine the implications of alternative technological growth rates on production capacity and conservation programs. USDA will project the impact of the higher growth rate for research and extension expenditures needed to maintain the historic 1.6 percent rate of growth in technology. USDA will also project a decline in real expenditures for research and extension and a corresponding lower rate of technological growth.

Projections of Crop Yields

Projections of crop yields are highly uncertain and are based on different assumptions. The ESCS-NIRAP projections simulate future yields using a computer program that is still being refined. A national linear programming model (see chapter 7, section C) uses projected yields estimated by a different procedure. The yield projections of the two systems, however, are fairly consistent. The NIRAP projections of average yields for the eight major crops--which accounted for 88 percent of the acreage harvested between 1966 and 1975--are projected to increase by 1 percent per year from the 1975-77 base period to the year 2030. This increase contrasts with the 2 percent average annual increase from 1950 to 1975.

Potential Environmental Concerns

The impact of environmental quality regulations has increased considerably

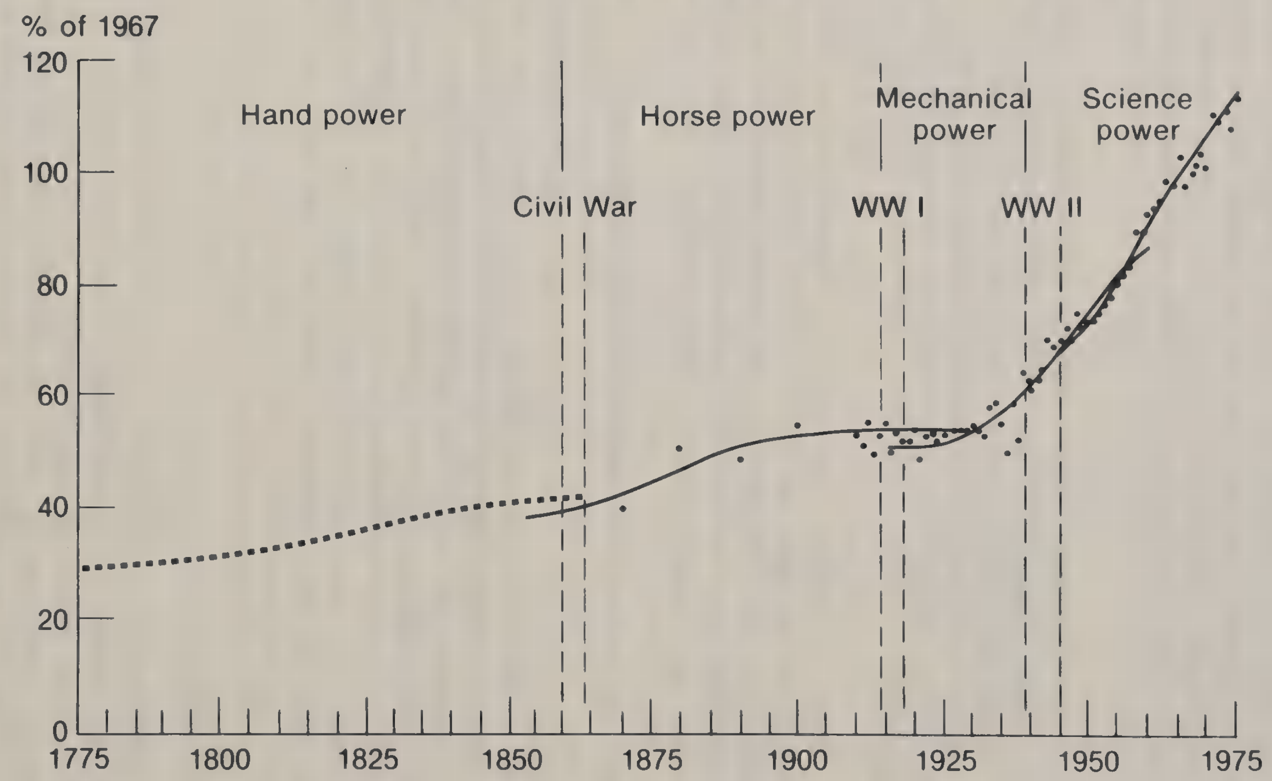


Figure 2-3.--Growth in American agricultural productivity, 1775-1975. The different growth curves represent the different eras. Source: USDA-ESCS. 1979. Agric. Econ. Rep. No. 435.

during the 1970's. A reasonable assumption, based on information from the Council on Environmental Quality (CEQ), is that environmental regulations will reduce the GNP's growth rate over the next two decades by about 0.2 percent annually (Data Resources, Inc., 1979). Some of these regulations are discussed in the following paragraphs.

- Pesticides. One constraint on the use of minimum tillage is the increased need to use herbicides, insecticides, and other chemicals. Concern for the environmental impact of some of these chemicals may result in legal restrictions on pesticide use. Such restrictions affect the feasibility of minimum tillage. Scientists are now developing integrated pest management systems that take biological and cultural pest control methods into account in minimum tillage ecosystems to reduce reliance on chemical pesticides. Therefore, technology is expected to keep pace with the pest control requirements of minumum tillage.

- Water quality. There is continuing pressure to maintain or improve water quality. The federal government expects to achieve its goals for water quality, although perhaps not as soon as expected. USDA will address the issue of water quality when agricultural activities could harm natural perennial streams, other water bodies, or ground water. USDA will also continue to emphasize the need to ensure a dependable water supply. In addition, demands for higher water quality will restrict the agricultural use of water. Future irrigation systems will therefore emphasize closed water transport systems and practices that promote more efficient water use.

- Wetlands. The Fish and Wildlife Service is conducting a National Wetlands Inventory. Present plans indicate that this inventory will not survey all wetlands in the Nation. This inventory plus action by environmental groups will keep the protection of wetlands an active issue. Government actions at all levels will probably continue to restrict the development of wetlands. But, if economic returns are sufficient, the private sector will most likely continue to drain, clear, and farm wetlands without government assistance.

- Surface mining. The Surface Mine Reclamation Act of 1977 and state laws will emphasize the need for reclaiming land that has been surface mined for coal. The scope of these laws will probably be expanded to cover all mining operations.

- Rare and endangered species. Government and private efforts to protect rare and endangered species of wildlife and plants will continue. As the identification and knowledge of plant species increase, these protection efforts could significantly affect USDA programs.

Demands for Recreation

The demand for recreation will probably grow, particularly in urban and urbanizing areas served by public transportation systems. Both the public and private sectors are expected to provide more opportunities and facilities for recreation. Legislation has created areas set aside specifically for recreation (the National Recreation Areas and the National Trails System, for

example). Legislation and other pressures will continue to restrict the use of some land to recreational purposes only.

Existing programs, based on legislation such as the Water Quality Act and on associated water quality standards, could increase the demand for water-based recreation and facilities for boating, swimming, fishing, and hunting. These activities and facilities will likely create demand for legal access to streambanks and for adequate streamflow levels.

Availability and Cost of Energy

Energy availability and costs may affect agricultural production more than any other supply factor. Other variables, such as technological and institutional changes, may become of secondary significance.

The extent to which real economic growth will change from present levels will depend on the policies and programs that affect energy supplies and demands. The effect of higher prices for imported oil will gradually lessen in relation to total aggregate demand, especially as increased energy prices lead domestic producers to develop alternative energy sources. The net reduction in aggregate consumer demand caused by higher oil prices will be about 0.4 percent of the GNP in 1980. In the long run, higher oil prices might lower the GNP growth rate by 0.1 percent to 0.2 percent per year until 1985.

The overall result will be a tendency for average energy prices to increase more rapidly than prices in general, at least to the end of the century. Imported oil will continue to set the marginal cost of energy, at least during the next decade. For RCA analyses, USDA assumed no change in the real price of energy.

Potential Cropland

Of the land not now cultivated, about 40 million acres have high potential for conversion to cropland and about 95 million acres have medium potential (USDA, 1978). Adding these 135 million acres to the 413 million acres already cultivated in 1977 gives a total potential cropland base of about 548 million acres in the United States. However, the acreage of potential cropland includes about 18 million acres of marginal cropland that are now cultivated but have severe limitations for cropland use.

Demand for Water from Sources Outside Agriculture

For the RCA reports, part of the information on water requirements for specific uses was obtained from the Second National Water Assessment conducted by the Water Resources Council (USWRC, 1978b). The Water Resources Council developed national estimates of water use to indicate current (1975) requirements and to project future demands for water use outside agriculture in the year 2000. Continued emphasis will be placed on instream flow needs, not only to meet the needs of downstream users, but also to meet esthetic needs and to sustain fish and wildlife.

Availability of Water for Agriculture

Agriculture will continue to be the largest user of water nationally. Increased competition for existing water will likely increase the cost of water for irrigation, but it will also place greater emphasis on efficient irrigation and better irrigation methods, systems, and management. It is possible that with declining water tables and increasing costs of energy and equipment, the current practice of pumping water from deep aquifer ground water will no longer be economical. In some areas, ground-water mining (see glossary) may be phased out by the year 2000 if the rapidly declining water tables make it economically unfeasible.

Water Rights

Water rights in the western states are assumed to remain under the existing appropriation system. Some changes in the ability to reallocate water will cause water to be shifted from agriculture to energy development or other nonagricultural uses. These changes, in effect, will tend to increase the price of water for all uses. The eastern states will probably regulate water rights primarily to meet water quality goals and requirements.

Flood Plain Development

As a result of disastrous floods throughout the country, the number of regulations restricting the use of flood plains has grown. This trend is expected to continue. Some techniques for restricting and regulating flood plain development are zoning restrictions, storm water management plans for watersheds, flood proofing buildings, restricting development, and relocation assistance.

References

Data Resources, Inc. 1979. The macroeconomic impact of federal pollution control programs, 178 assessment. (Submitted to the Environmental Protection Agency and the Council on Environmental Quality.)

Lu, Yao-chi, and Leroy Quance. 1979. Agricultural productivity: Expanding the limits. U.S. Dep. Agric., Agric. Inf. Bull. 431, 11 pp.

United State Department of Agriculture, Soil Conservation Service. 1978. 1977 National resources inventories.

United States Department of Commerce. 1977. Population estimates and projections. Series P-25, No. 704.

United States Department of Commerce. 1979. 1979 OBERS projections: Economic activity in the United States. Vol. 1, Concepts, methodology, and state data. (Draft)

United States Water Resources Council. 1974. 1972 OBERS projections: Economic activity in the United States. Vol. 1, Concepts, methodology, and summary data.

United States Water Resources Council. 1978a. Guideline 2: Agricultural price standards.

United States Water Resources Council. 1978b. The Nation's water resources 1975-2000. Functional water uses. Second Natl. Water Assess. Part III Draft.

Chapter 3 - Analyses of Potential Problem Areas

The RCA Process

The Resources Conservation Act (RCA) states that the soil and water conservation programs of the United States Department of Agriculture shall be responsive to the long-term needs of the Nation. In carrying out its responsibilities for nonfederal lands under RCA, the Department is to--

- o appraise the current status and condition of the soil, water, and related resources on nonfederal land.

- o determine what problems will be encountered in meeting projected demands for food, fiber, and environmental quality.

- o determine which of those problems can and should be addressed by a USDA soil and water conservation program.

- o recognize and use resource information available from federal, state, and local governments, private organizations, and other sources.

- o coordinate resource appraisal under RCA and the resource assessment conducted under the Forest and Rangeland Renewable Resources Planning Act (RPA).

Although the Soil Conservation Service was made responsible for administering the Act, the Secretary of Agriculture recognized that all USDA programs and agencies involved in soil and water conservation must be directly involved in RCA activities. To provide direction, the Secretary established an RCA Coordinating Committee with representatives from eight USDA agencies--the Agricultural Stabilization and Conservation Service (ASCS); Economics, Statistics, and Cooperatives Service (ESCS); Farmers Home Administration (FmHA); Forest Service (FS); Rural Electrification Administration (REA); Science and Education Administration (SEA); Soil Conservation Service (SCS); and Office of Budget, Planning, and Evaluation (OBPE). These agencies direct 34 different soil and water conservation programs. In addition to the USDA agencies, the Secretary asked the Office of Management and Budget (OMB) and the Council on Environmental Quality (CEQ) to join the committee.

The major tasks of the coordinating committee were to review and analyze data, involve the public, and present the results in a form useful for making policy decisions.

The committee first developed a systematic process for accomplishing its major tasks. This process was described in "RCA Process," which was distributed widely to ensure that individuals and organizations concerned with soil and water conservation would know the steps taken by the committee.

The following are the basic steps in the RCA process:

1. Appraise the resources.
2. Project demands and the resources required to meet those demands.

3. Analyze the appraisal and projected demands to identify and quantify problems in selected potential problem areas and to determine alternative levels for desired objectives.
4. Establish USDA soil and water conservation objectives.
5. Develop and compare alternative strategies to meet the objectives.
6. Select one of the alternative strategies to accomplish the recommended USDA soil and water conservation program.

Figure 3-1 gives a schematic description of the general RCA process.

Appraising Resources

The first step under RCA was to identify the extent of the resource problems. This required an appraisal of the status and present condition of soil, water, and related resources. This information is published in Part I of the 1980 RCA Appraisal. Figure 3-2 is a detailed flow diagram of the steps in the appraisal.

Resource Analysis

To define the scope of the analyses, the committee defined seven potential problem areas:

1. The quantity and quality of soil resources for food and fiber production
   (Providing an adequate supply of food and fiber through conservation, use, and development of soil and water resources through the year 2030.)
2. Water quality
   (Influencing agriculture, silviculture, and land use to help meet state and national water quality objectives.)
3. Water supply and conservation
   (Meeting current and future water needs that require withdrawing water from streams, reservoirs, ground water aquifers, and lakes for irrigation, livestock, farms, and rural communities. In addition, meeting the water needs of agriculture by managing soil moisture.)
4. Fish and wildlife habitat
   (Improving the quality of habitat on cropland, forest land, and rangeland; increasing the diversity of habitat on cropland; and reducing the annual loss of wetlands.)
5. Upstream flood damages
   (Reducing flood damages in upstream areas.)
6. Energy conservation and production
   (Minimizing energy consumption in agriculture and encouraging the use of agricultural products in generating energy.)
7. Related natural resources
   (Improving organic waste management, increasing opportunities for outdoor recreation, and improving management of soil and water resources in urbanizing areas.)

These potential problem areas match the resource areas that the public has considered most serious. The analyses of future demands and resource capabilities were centered around these potential problem areas. The Department

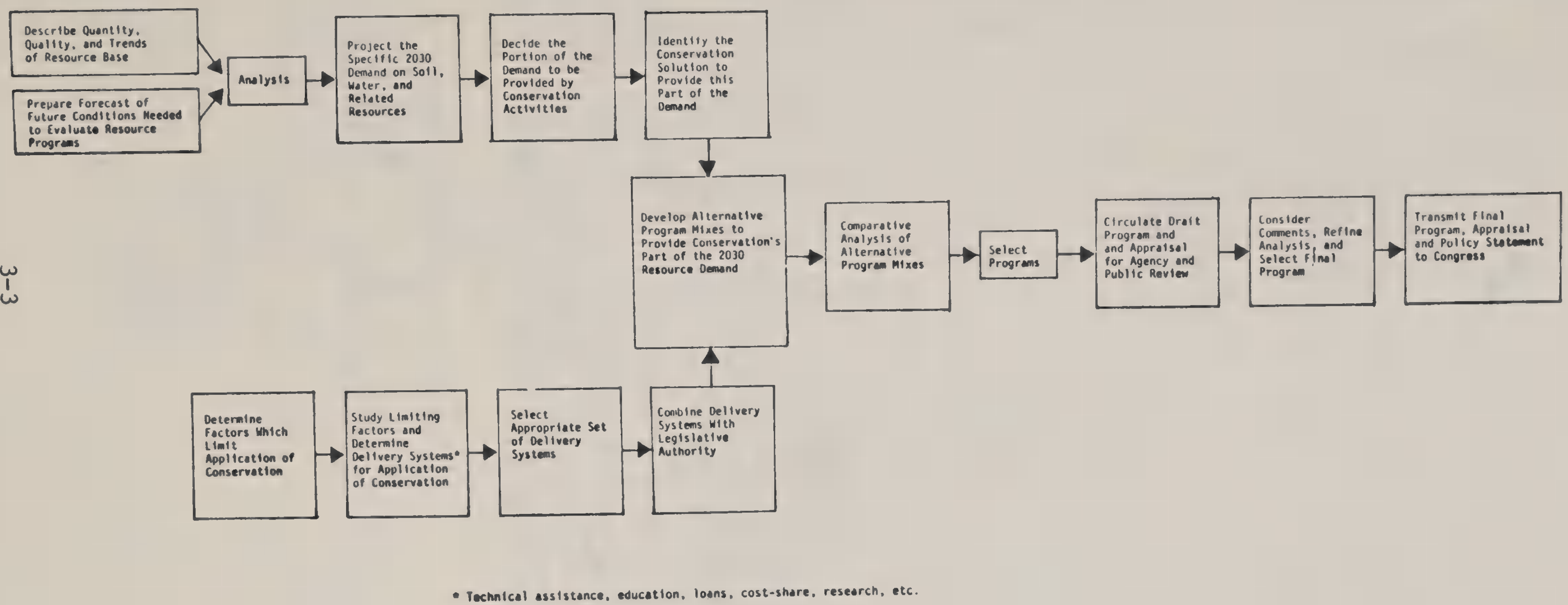


Figure 3-1.--General steps in the RCA process.

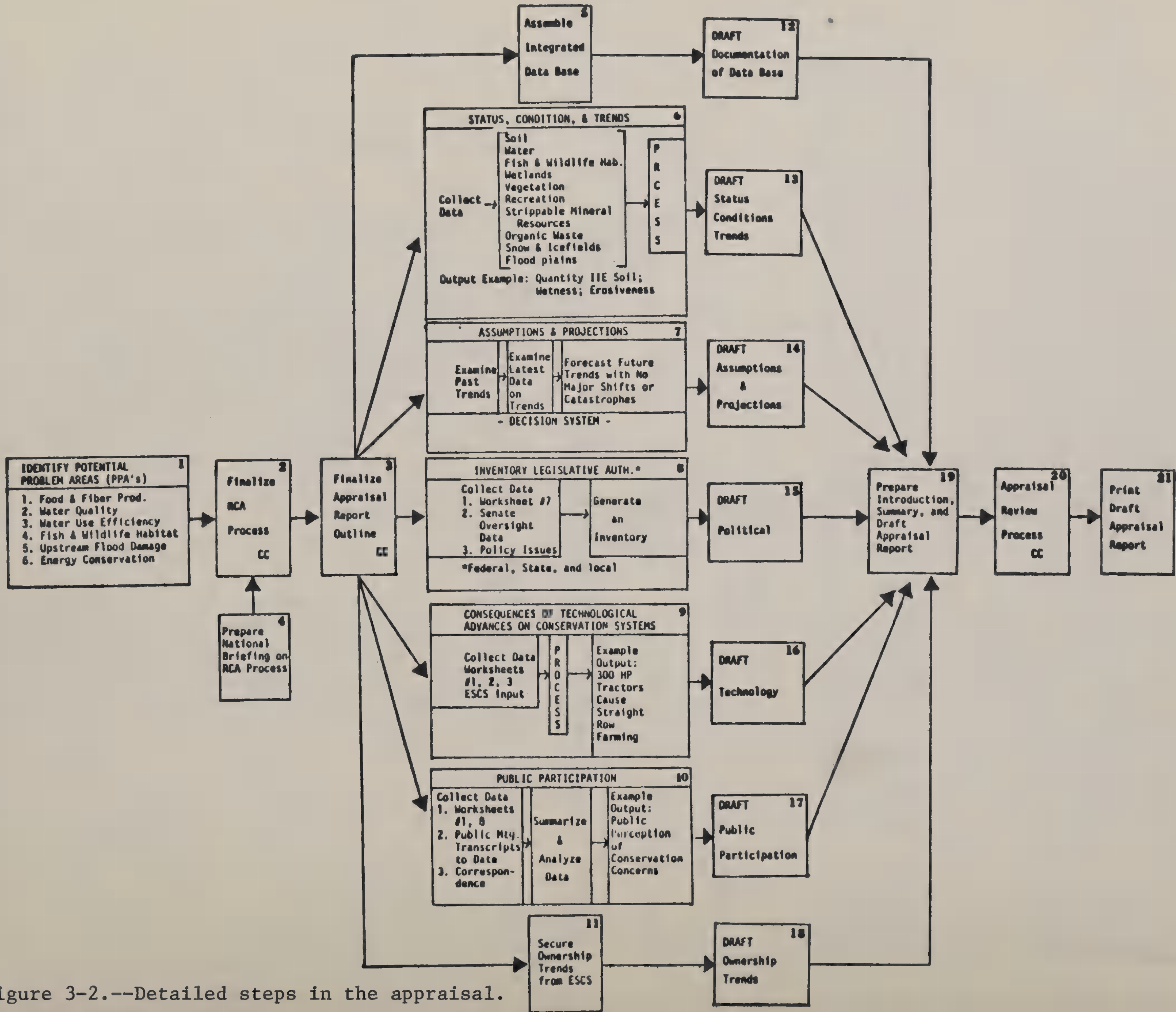


Figure 3-2.--Detailed steps in the appraisal.

compared the present status and condition of resources to projections of future demands on them. This enabled USDA to determine the ability of these resources to meet future demands and to identify specific problems that may arise if those demands are met.

In trying to find ways to solve these problems, USDA tried to use a "zero base" approach, i.e., to start with no preconceived ideas of how much of the problem it should resolve or how existing programs could solve it. The analysis procedure is shown in steps 22 through 25 of figure 3-3. The results of the analysis are presented later in this introduction.

Objectives

After specific problems were identified, the RCA Coordinating Committee established objectives for USDA conservation programs. If there were sufficient data on a problem, the objectives were set at quantifiable levels. Steps 25.3 to 37 in figure 3-3 show how USDA set the objective levels. The results are presented in the RCA Program or will be printed in subsequent reports.

Alternative Strategies

Using the "zero base" approach, USDA prepared a series of alternative strategies to achieve RCA objectives. Each strategy consists of a group of logically consistent activities that will achieve an identified portion of the overall objective. At this point, USDA considered legislative and policy constraints and how they affected each strategy. The RCA Coordinating Committee specified delivery mechanisms, such as technical assistance, education, loans, cost sharing, and tax incentives, as part of each strategy. These activities are shown in steps 25 through 34 in figure 3-3.

Comparison and Selection of Strategies and Program Needs

USDA analyzed and compared the practicability, feasibility, and acceptability to the public of the alternative strategies. The Department then selected several alternative strategies to be included in the Program Report for further consideration by the public. This phase is shown in steps 38 through 45 in figure 3-3.

Circulation of Drafts

USDA is making the drafts of RCA reports available to the public for review and comment. The Department will hold field meetings to provide information on the reports and answer questions. After the public has reviewed the reports, USDA will analyze and consider all comments in selecting a strategy. This review and final decision phase is shown schematically in figure 3-4.

Final Program

Once a strategy has been selected, the Administration will develop one USDA soil and water conservation program. The Department will prepare the final version of the Appraisal and The Soil and Water Conservation Program Report, and the President will present it to the Congress.

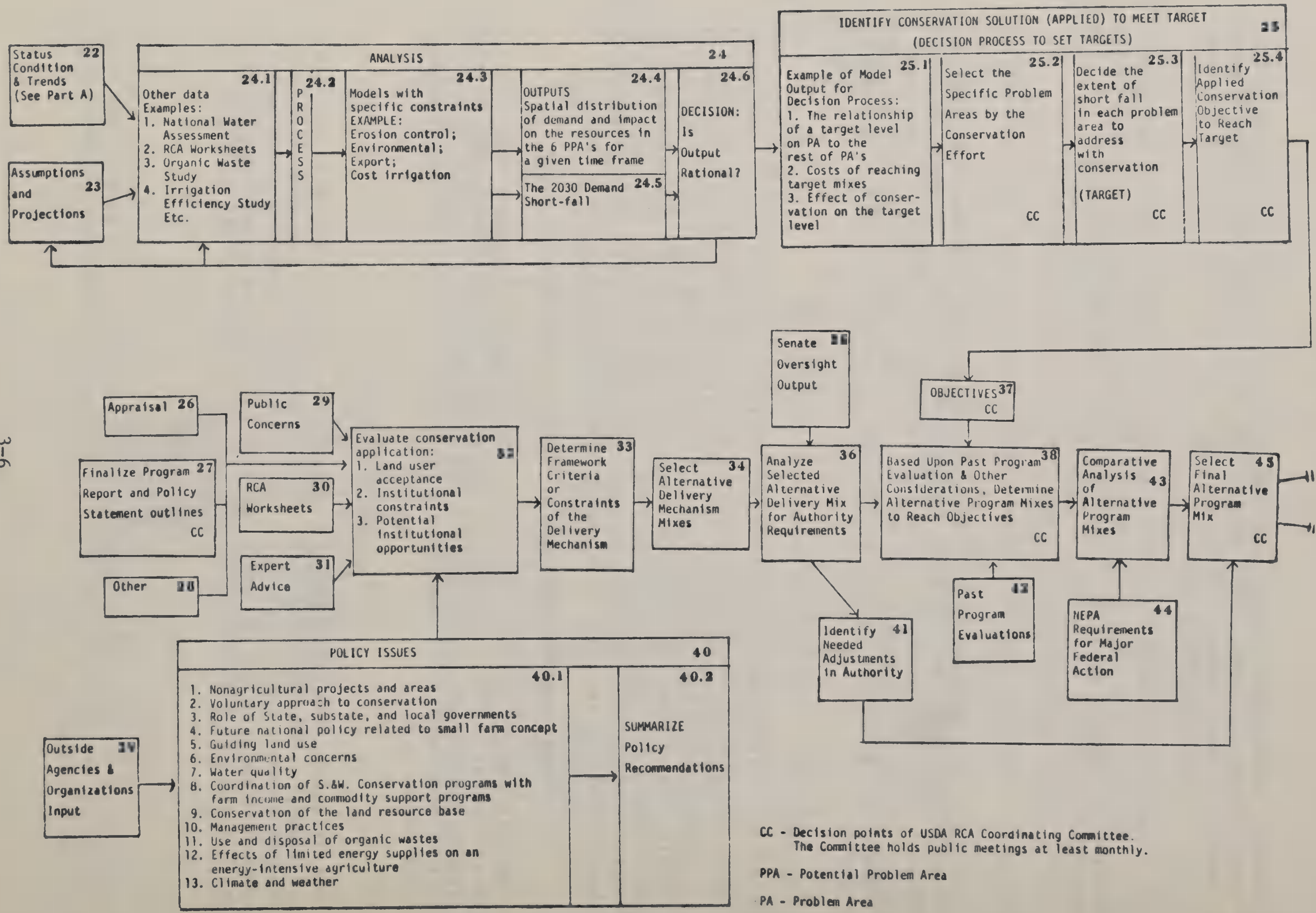
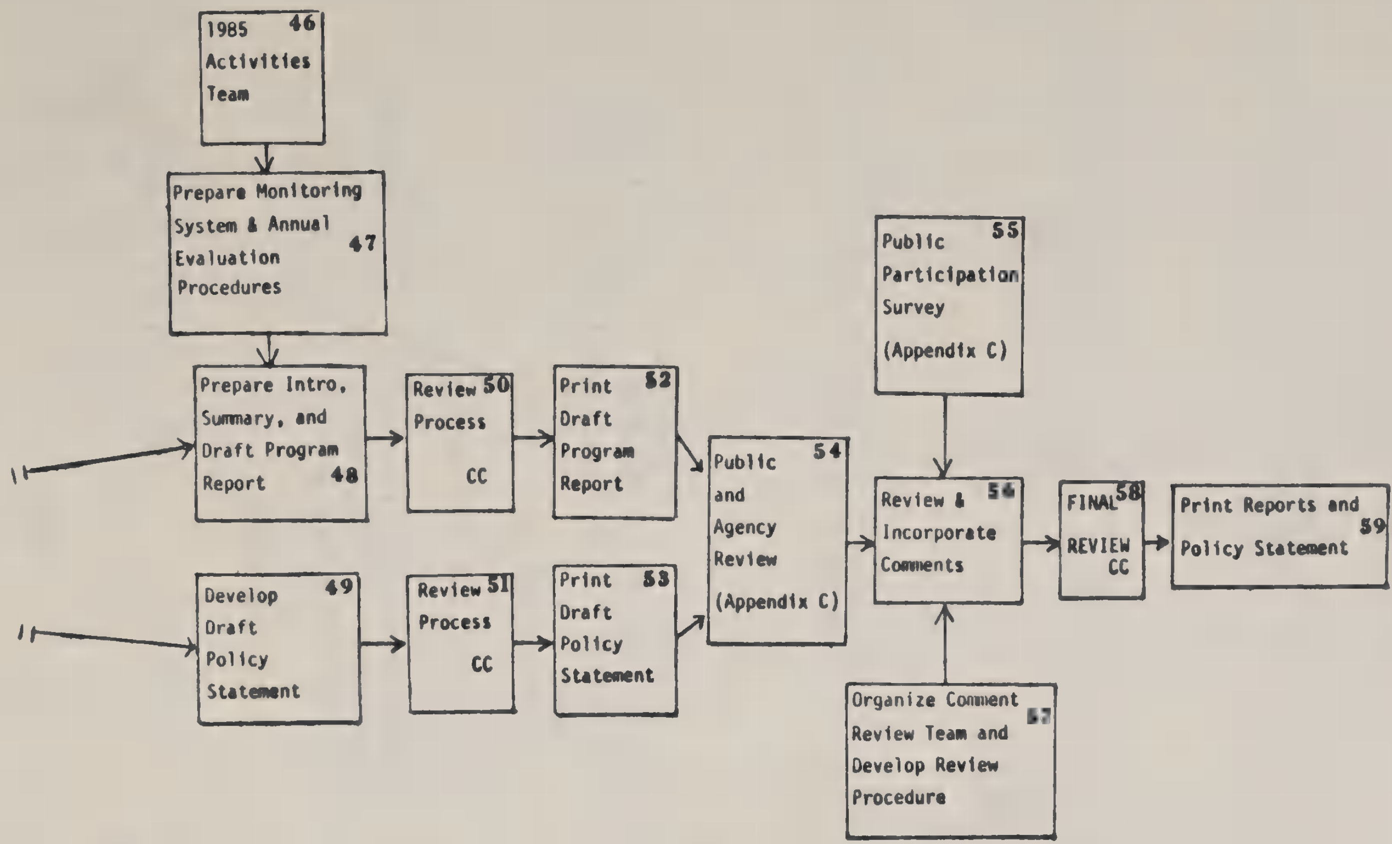


Figure 3-3.--Program report and policy statement (part A).



CC - Decision points of USDA RCA Coordinating Committee.
The Committee holds public meetings at least monthly.

PPA - Potential Problem Area

PA - Problem Area

Figure 3-4.--Program report and policy statement (part B).

The Analysis for RCA

The rest of chapter 3 describes and analyzes seven potential problem areas (PPA's). USDA analyzed each PPA using the following format--(1) problem statement; (2) scope; (3) focus; (4) results of the analysis; (5) alternative objective levels; and (6) recommendations for future analysis. Each of these steps is described below.

Problem Statement

This section provides a brief description of the problems associated with a PPA. When the analysis of a PPA involved a detailed examination of actual resource data, the problem statement was considerably expanded.

Scope

The scope of the analysis delineates how much of the total problem area USDA analyzed. For example, though water quality problems caused by organic wastes are a significant national problem, USDA might analyze only that portion that stems from agriculture.

Focus

The focus of the analysis indicates which aspects of a problem USDA analyzed in detail and which aspects will receive attention in Department programs.

Results of the Analysis

The results of the analysis offer a more complete understanding of the location and extent of critical resource problems. They also provide better estimates of the results of existing or projected trends that affect soil and water resources. This information provides an understanding of the need for specific action in conservation programs.

USDA analyzed and displayed data for the smallest geographic areas feasible. The areas used were (1) national; (2) regional (agricultural production regions and water resource regions); (3) states; (4) aggregated subareas (ASA's); and (5) producing areas. USDA also used additional classification systems as needed to aid analysis of particular problems.

Alternative Objective Levels

The analysis generally provided insight into possible levels of achievement of objectives in each problem area. Alternative objective levels were identified that gave the RCA Coordinating Committee a starting point in selecting a target objective level. In designating objective levels, USDA based its selection on legal, economic, environmental, social, and other grounds as appropriate.

Recommendations for Future Analysis

In all cases, the analysis for the 1980 reports was based on existing data. In certain potential problem areas, e.g., soil resources, a wealth of data was available for analysis. However, in some PPA's data were scarce, techniques were not available to analyze the data, or both. Under such circumstances, USDA relied on experienced technical judgment to obtain the best information possible. In planning for the 1985 RCA reports, USDA will give priority to those areas where there are shortcomings in data and methodology.

Section A-Potential Problem Area 1, Soil Resources: Quantity and Quality for Food and Fiber Production

Problem Statement

Historically, most of the food and fiber in the United States has been produced on private lands. The Nation's soil and water resources and agricultural technology have generally supplied us with an abundance of agricultural commodities. A major objective of the U.S. Department of Agriculture's soil and water conservation programs has been to ensure that the Nation's soil and water resources will have the capacity to meet future demand for food and fiber.

Changes in population have an important effect on the demand for agricultural commodities and, hence, on the demand for resources to produce them. The population of the United States was about 215.2 million in 1976. Population projections by the U.S. Department of Commerce for the year 2030 range from 249 million to 392 million (U.S. Dep. Commerce, 1977). The baseline, or "best guess," projection is that the population is likely to be about 300 million by 2030. This would be an increase of 85 million over the next 50 years.

Disposable income is a second factor that strongly affects the demand for agricultural production. Disposable income is projected to increase from the 1976 figure of $4,148 per capita to more than $14,000 by 2030. Although the percentage of real income spent for food is expected to remain relatively constant at about 17 percent, USDA expects that Americans will eat more meats and fresh fruits.

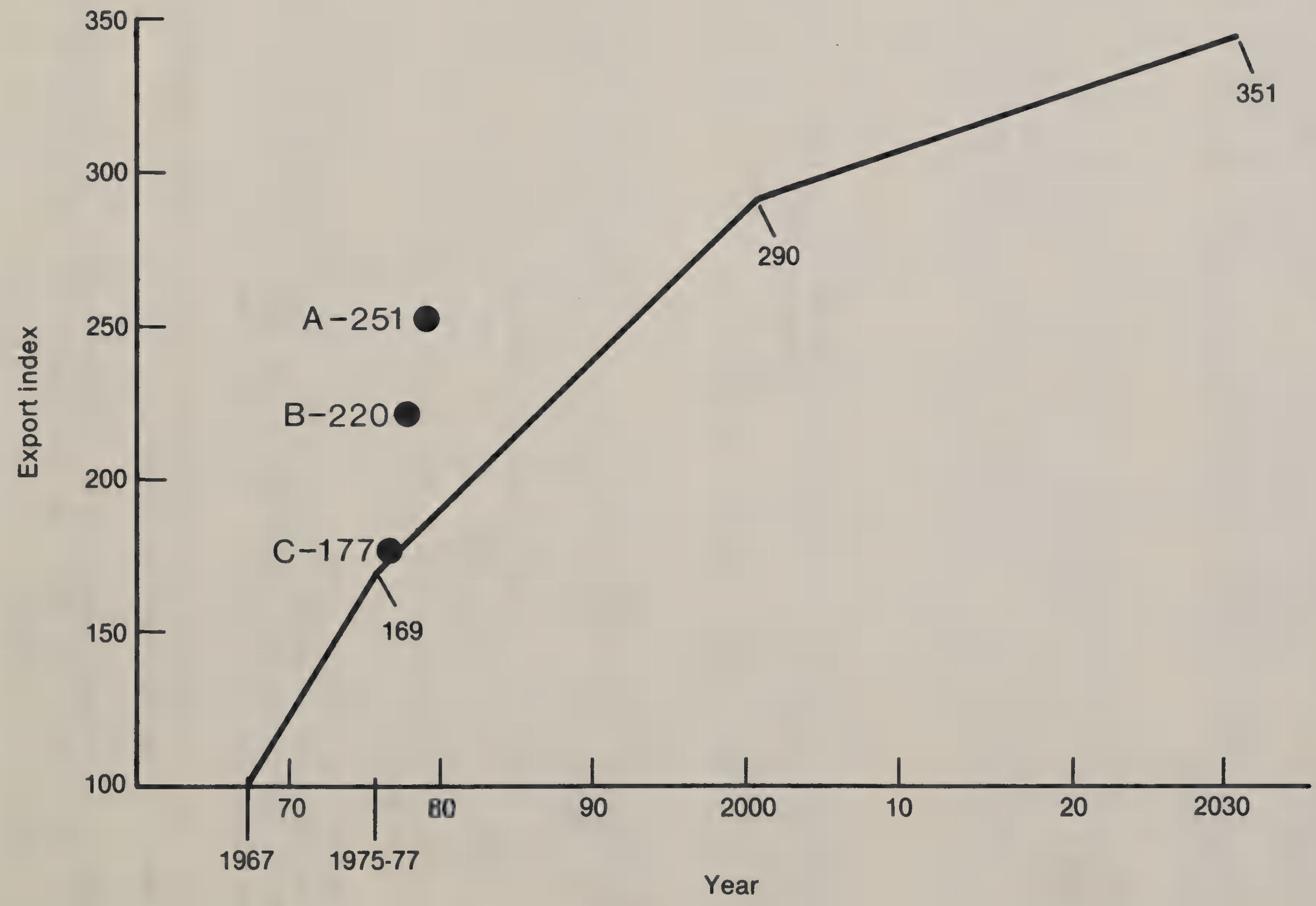
The rate of growth of agricultural exports is a third factor that will influence future demand for agricultural products. Exports increased by about 77 percent between 1967 and 1977. USDA projections indicate that by 2030 exports could increase by more than 200 percent above the 1975-77 levels. Figure 3A-1 shows the current export levels and the projected export levels through 2030. Points A, B, and C on the figure show actual exports for 1979, 1978, and 1977, respectively. If the growth in exports continues to follow the trend of the last 3 years, the export projections used for the RCA analysis will be low.

These three factors--population, income, and exports--may put pressures on the resources to produce at much higher levels than in the past. Other factors will help determine the capacity of the Nation's soil and water resources to meet these future demands. Among these factors are:

1. The effect of soil erosion and deterioration of grazing resources on the ability of American agriculture to produce.

2. The effect of bringing new lands into production, availability of water, irrigating more land, and improving drainage of currently cropped land on the effective size of the resource base.

3. The effect of development and implementation of technology on crop yields.



A –251 = 1979 Level of Exports (Estimated)
B –220 = 1978 Level of Exports
C –177 = 1977 Level of Exports

Figure 3A-1.--Current and projected export levels.

On the following pages, some of the problems facing the soil and water resource base are examined in more detail.

Potential Deterioration of Soil Resources.--The 1977 National Resource Inventories (NRI) (USDA, 1978b) show that erosion is the main conservation problem on more than half of the Nation's cropland. Soils in subclass "e" (erodible) are by far the largest group of problem soils. (See "land capability classes and subclasses" in the glossary.) For example, the NRI show that in 1977 average annual erosion exceeded 5 tons per acre on most of the acreage in each land class used for row crops in the Southeast Farm Production Region. Erosion rates in 1977 were more than 10 tons per acre on 32 percent of the lands used for row crops in the Southeast, 9 percent in the Northeast, and 19 percent in the Corn Belt. A 10 ton per acre per year erosion rate is the equivalent of removing 1 inch of topsoil every 15 years.

Table 3A-1 shows the extent of sheet and rill erosion on cropland and the amount of sheet and rill erosion in excess of 5 tons per acre per year, by erosion interval. The NRI show that sheet and rill erosion removes about 1.97 billion tons of soil from cropland in the United States each year, including about 1 billion tons from lands that are eroding at rates of more than 5 tons per acre per year. Although the erosion rate is more than 5 tons per acre per year on only 23.5 percent of the Nation's cropland, these lands account for about 51 percent of all sheet and rill erosion.

For the RCA analysis, USDA examined more than 1,100 published soil surveys. It summarized data on present crop yields and on the depths of the topsoil in these survey areas by land capability subclass or groupings of subclasses. These data show, for example, that the topsoil in more than 80 percent of the soils in class I is less than 17 inches thick. In subclass IIe, the topsoil is less than 10 inches thick in 70 percent of the soils and less than 12 inches thick in 86 percent of the soils. For additional information on the data summarized from the 1,100 soil surveys, contact Ernest V. Todd, RCA Manager, Room 5123, P.O. Box 2890, Washington, D.C. 20013.

Analyses of these data, as presented in table 3A-2, show how present erosion rates, if allowed to continue, could reduce potential productivity in seven crop producing areas over the next 50 years. The Corn Belt is an example of an area with regional erosion problems. It is one of the most productive farming areas in the world, but about 43 percent of the land used for row crops in the Corn Belt is composed of highly erodible soils. If erosion in this area were allowed to continue at 1977 rates, potential corn and soybean yields would probably be reduced by 15 to 30 percent by 2030. For example, note the reduction in corn yields in producing area 43 (table 3A-2).

In other areas and for other crops, the impact of erosion on yields is not as dramatic. Still, relatively shallow topsoil depths and high erosion rates can significantly reduce productivity on soil groups 3, 4, and 5 over the long term (see table 3A-2).

Potential Deterioration of Grazing Resources.--There are 432 million acres of nonfederal rangeland and native pasture. In 1976, the latest year for which data are available, 68 percent of this acreage was reported as properly grazed, and 32 percent was reported as overgrazed. Rangeland productivity is estimated to be 55 to 60 percent of potential.

Table 3A-1.--Extent of sheet and rill erosion on cropland and the amount of sheet and rill erosion in excess of 5 tons per acre per year, by erosion interval

Erosion interval	Thousands of acres	Cumulative percentage of acres	Total erosion in excess of 5 tons per acre per year	Cumulative percentage of erosion in excess of 5 tons per acre per year
Tons per acre per year			(1,000 tons)	
0-1	128,186	31.0	0	0.0
1-2	72,596	48.6	0	0.0
2-3	51,619	61.1	0	0.0
3-4	37,060	70.1	0	0.0
4-5	26,693	76.5	0	0.0
5-6	18,661	81.0	7,464	0.7
6-7	13,659	84.3	19,123	2.6
7-8	9,794	86.7	23,506	5.0
8-9	7,667	88.6	26,068	7.5
9-10	6,143	90.0	27,029	10.2
10-11	4,985	91.3	26,919	12.9
11-12	3,754	92.2	24,026	15.2
12-13	3,027	92.9	22,400	17.5
13-14	2,770	93.6	23,268	19.8
14-15	2,403	94.1	22,588	22.0
15-20	7,714	96.0	95,654	31.4
20-25	4,382	97.1	76,247	39.0
25-30	2,891	97.8	64,758	45.4
30-50	5,469	99.1	191,415	64.3
50-75	2,240	99.6	128,800	77.0
75-100	777	99.8	64,103	83.4
100+	712	100.0	168,032	100.0
Total	413,202	----	1,011,398	----

Source: USDA, 1978b.

Table 3A-2.--Expected changes in yields of selected crops in seven producing areas if 1977 erosion rates continue for the next 50 years

Crop and producing area	Soil group 1/	1977 annual rate of erosion	Cumulative soil loss over 50 years	Present yield	Maximum potential yield in 2030 2/	Yield in 2030 if present erosion rate continues	Percentage of maximum yield in 2030 3/
		(Tons per acre)	(Inches)	(Units) 4/	(Units) 4/	(Units) 4/	(Percent)
Corn	1	2.5	0.8	101	152	152	100
10	2	5.5	1.8	81	121	120	99
(Pennsylvania	3	8.1	2.7	74	111	107	96
and New York)	4	9.2	3.1	66	99	91	92
	5	13.6	4.5	67	101	94	93
Cotton	1	3.2	1.1	524	787	787	100
14	2	6.2	2.1	388	583	573	98
(South	3	15.7	5.2	315	472	341	72
Carolina and	4	22.2	7.4	244	367	256	70
Georgia)	5	17.4	5.8	227	341	250	73
Soybeans	1	3.2	1.1	24	36	36	100
14	2	6.2	2.1	20	30	29	99
(South Carolina	3	15.7	5.2	17	25	21	82
and Georgia)	4	22.2	7.4	14	22	12	56
	5	17.4	5.8	12	18	16	93
Corn	1	3.9	1.3	105	157	156	99
35	2	4.1	1.4	87	131	128	98
(Illinois and	3	13.2	4.4	76	113	97	86
and Ohio)	4	25.4	8.5	66	99	60	61
	5	42.4	14.1	61	92	50	54
Soybeans	1	3.9	1.3	33	50	49	99
35	2	4.1	1.4	29	43	43	99
(Illinois and	3	13.2	4.4	24	36	31	87
Ohio)	4	25.4	8.5	20	31	22	73
	5	42.4	14.1	17	26	17	67

Table 3A-2.--Expected changes in yields of selected crops in seven producing areas if 1977 erosion rates continue for the next 50 years--Continued

Crop and producing area	Soil group 1/	1977 annual rate of erosion	Cumulative soil loss over 50 years	Present yield	Maximum potential yield in 2030 2/	Yield in 2030 if present erosion rate continues	Percentage of maximum yield in 2030 3/
		(Tons per acre)	(Inches)	(Units) 4/	(Units) 4/	(Units) 4/	(Percent)
Soybeans	1	3.2	1.0	34	51	51	100
41	2	4.9	1.6	29	44	43	98
(Iowa)	3	16.6	5.6	26	39	33	85
	4	18.0	6.0	23	35	21	59
	5	32.2	10.7	20	30	24	79
Corn	1	4.0	1.3	91	137	137	100
43	2	5.1	1.7	74	111	110	99
(Illinois and	3	18.5	6.2	71	107	90	84
Missouri)	4	14.7	4.9	62	93	76	82
	5	31.5	10.5	50	75	53	71
Cotton	1	3.4	1.1	322	483	482	100
68	2	3.5	1.2	229	343	342	100
(Oklahoma)	3	2.9	1.0	218	327	326	100
	4	5.5	1.8	210	315	315	100
	5	2.6	0.9	175	263	260	99
Wheat	1	3.4	1.1	28	42	42	99
68	2	3.5	1.2	20	31	30	97
(Oklahoma)	3	2.9	1.0	18	27	26	97
	4	5.5	1.8	17	26	25	96
	5	2.6	0.9	14	22	19	90

Table 3A-2.--Expected changes in yields of selected crops in seven producing areas if 1977 erosion rates continue for the next 50 years--Continued

Crop and producing area	Soil group 1/	1977 annual rate of erosion	Cumulative soil loss over 50 years	Present yield	Maximum potential yield in 2030 2/	Yield in 2030 if present erosion rate continues	Percentage of maximum yield in 2030 3/
		(Tons per acre)	(Inches)	(Units) 4/	(Units) 4/	(Units) 4/	(Percent)
Cotton	1	4.0	1.3	332	498	497	100
71	2	4.3	1.3	247	370	365	99
(Texas)	3	7.1	2.4	225	338	329	97
	4	6.9	2.3	218	328	322	98
	5	5.0	1.7	206	308	308	100
Grain Sorghum	1	4.0	1.3	58	88	88	100
71	2	4.3	1.4	44	67	66	99
(Texas)	3	7.1	2.4	40	60	59	98
	4	6.9	2.3	38	57	57	99
	5	5.0	1.7	38	57	57	100

1/ Soil groups are made up of aggregations of land capability classes and subclasses in the following manner:

Soil group	Land capability class and subclass
1	I
2	II, IIIs, IIIc, IIIw, IVs, IVc, IVw, V
3	IIIe
4	IVe
5	VI, VII, VIII

2/ Based on 1 percent annual increase in yields resulting from technology.

3/ Percentages were calculated from unrounded data and therefore may not represent the ratio between the numbers shown for maximum potential yield and eroded yield.

4/ Units are in bushels for all crops but cotton, which is shown in pounds.

Generally, deterioration in range condition reduces forage production and increases susceptibility to erosion (Branson, Gifford, and Owen, 1972). USDA estimates indicate that range condition has improved considerably in recent years. Between 1963 and 1977, the percentage of range in excellent condition increased from 5 to 12 percent, the percentage in good condition increased from 15 to 28 percent, the percentage in fair condition increased from 40 to 42 percent, and the percentage in poor condition decreased from 40 to 18 percent. In 1977, range condition was improving in 13 of the 17 major range states, was static in three, and was declining in one. In spite of recent improvement, however, 60 percent of the nonfederal rangeland is still in poor or fair condition.

Encroaching brush and weeds can significantly reduce the productivity of range. The invasion of mesquite in 130 counties in west Texas reduced forage by 0.9 to 1.8 million animal unit months in 1971 (Osborn and Witkowski, 1974). (See the glossary for a definition of animal unit months.) The value of the forage lost was $429 million in years of below average forage production and as much as $832 million in years of above average production. The NRI indicated that brush control is needed on 20 percent of the nonfederal rangeland--about 84 million acres.

Potential for Enlarging the Effective Cropland Base.--Future crop production in the United States could be increased by converting lands that are now used for range, pasture, forest, or other uses to cropland. The NRI show that 135 million acres of land that are not now cultivated have high or medium potential for conversion to cropland. Of this, 40.1 million acres have high potential and 94.9 million acres have medium potential for conversion.

Converting these lands to cropland would have its cost. Of the potential cropland, 32.9 million acres are now forest land, 53.6 million acres are pastureland and native pasture, 41.5 million acres are rangeland, and about 7 million acres are used for other purposes. In addition to the direct cost of converting these lands to cropland, conversion would also reduce the potential supply of the products that these lands now produce.

The conversion of these lands to cropland would also preclude their use for producing energy. The potential for energy production from these lands is discussed in section 3-F, Energy Conservation and Production. Despite the losses of forage, wood crops, and energy, however, converting this potential cropland could significantly increase the Nation's crop production.

Productivity could also be increased by improving the drainage on land that is now cultivated. The NRI show that of the 105 million acres of wet soils (capability classes IIw, IIIw, and IVw) that are now cultivated, about 34.2 million acres have drainage systems that are inadequate for maximum crop production. Crop yields on well drained soils can be as much as 50 to 100 percent higher than those on the same types of soils in poorly drained condition.

Improving drainage on these soils has its own special problems. A significant amount of the 34.2 million acres having inadequate drainage could be

classed as wetland types 1 and 2. On these lands, wetland values would be further damaged by providing adequate drainage. In addition, many of these wet soils lie next to significant areas of wetlands. Improved drainage of the presently cropped areas could result in direct drainage of the adjacent wetlands or damaging overflows from drainage outlets. Finally, many of these areas of wet soils serve to recharge ground water supplies. Improved drainage can reduce recharge and thereby lower the water table. Because drainage can have such far-reaching effects, proposals for major drainage programs cannot be made until all of the consequences of such actions are understood.

Scope

The level of demand placed on our agricultural resource base is determined primarily by the domestic population, the standard of living, and the volume of agricultural exports. The level of production will be determined by the availability and quality of resources available for agricultural production and the level of technology. USDA made specific assumptions regarding these levels of demand and supply in order to analyze future conditions. Table 3A-3 summarizes these assumptions. See also chapter 2 for more detail about the assumptions and projections that USDA used for this and other sections of the 1980 RCA Appraisal.

Projections of total agricultural production were made using three alternative levels of exports: no exports, the 1975-77 average level of exports, and a projected level of exports approximately double the 1975-77 level. Analyses of conservation options that considered demand for agricultural products for domestic consumption only, therefore, would be realistic only if the Nation were willing to forego the export market. See table 3A-4 for projections of exports of selected commodities.

Although the third alternative provides for doubling the 1975-77 level of agricultural exports by the year 2030, in the last 3 years the Nation has expanded exports substantially beyond this rate. Current USDA data indicate that by 1979, exports had already reached about 45 percent of the increase projected for 2030. The projected rate of export growth used for the 1980 RCA Appraisal, therefore, is quite conservative. However, even attempting to satisfy the domestic demand and the conservative projections of exports places very real stress on available resources.

In the analysis, it was assumed that agricultural productivity would increase by 1.1 percent per year from 1980 to 2000 and by 0.8 percent per year from 2001 to 2030. The reduction in the acreage required to support each American between 1910 and the mid-1970's reflects the influence of technology. The first significant reduction in per capita acreage requirements occurred in the early 1930's, when hybrid corn was introduced. Another major reduction occurred between the mid 1940's and the mid 1960's, when the per capita acreage requirements were reduced by about half as the use of agricultural chemicals--both fertilizers and pesticides--increased. Since the mid-1960's, the rate of technological improvement has slowed dramatically. Today, about 1.1 acres of farmland is required to satisfy the needs of each American (USDA, 1978a).

Table 3A-3.--Projection assumptions used for the 1980 RCA analyses

Factor	1976	2000	2030
U.S. population (millions)	215.2	260.4	300.3
Annual growth rate in agricultural technology (percent)	----	1.1	0.8
Agricultural productivity index (1967 = 100)	116	147	187

Table 3A-4.--Projected exports of selected commodities

Exports	Million units	Historic 1975-77	Historic 1977-79	Projected 2000	Projected 2030
Wheat	Bushels	1,082	1,239	1,999	2,411
Rice	Hundredweight	65	78	188	208
Soybeans	Bushels	606	762	1,436	1,866
Corn	Bushels	1,748	2,196	2,520	3,229
Sorghum	Bushels	233	221	322	413
Oats	Bushels	12	11	21	26
Barley	Bushels	49	44	79	101
Export index (1967 = 100)		169	216	290	351
Export growth rate:					
1976 to 2000 (Percent)		----	----	2.3	----
2000 to 2020 (Percent)		----	----	----	0.6

Focus

Three basic options can help American agriculture attain high levels of production: (1) protecting the agricultural resource base, (2) expanding the cropland base, and (3) increasing the rate at which technology is developed and applied. In choosing an option, one rationale calls for adopting the least expensive ways to increase the productive capacity of the resource base. A second involves selecting the option that provides the least degree of risk and irreversibility. For example, if the productive capacity of a soil is reduced through erosion, it will usually not be possible to reverse this loss. A third rationale calls for adopting quickly the option that takes the longest time to become effective. Only then would other alternatives be implemented. For example, the development and adoption of new technologies that could significantly increase average yields are likely to take a long time. Therefore, research on new technologies could not be delayed for long if higher production were required soon.

A focus that minimizes risk and irreversibility would give priority to the first option--protecting the resource base. If soils are allowed to erode or if grasslands are overused or degraded to the point where productivity is significantly reduced, it will be impossible, or very time consuming and expensive, to restore their productivity.

Expanding the usable cropland base through drainage and conversion--the second option--would probably give the greatest economic return for the investment. Positive results would appear soon after installation and, therefore, much less of the investment would have to be discounted. On the other hand, postponing these measures would probably not cause irreversible deterioration of the lands on which they could be applied except where the lands were converted to such uses as urban development or water storage. Postponing these actions would also delay the potential adverse environmental impacts that sometimes accompany them.

The third option would lead to action first to accelerate the development and adoption of technology that increases yields and only then to protect the resource base. This type of action requires a long time to show results--much more so than drainage of wet soils on lands now cropped and conversion of lands now in other uses.

Results of the Analysis

The RCA analysis used the CARD-USDA National Agricultural Linear Programming Model (see chapter 7, section B). The model cannot and is not intended to duplicate the real world. Because data and analytical constraints always limit the realism of a model, the results cannot be taken as absolute measures of impacts. Instead, the results indicate the expected direction of response and the relative magnitude of that response.

The model is designed to select the least expensive way of achieving a given level of production. For example, if the requirement is to produce 1 bushel of corn, the model searches for the location where corn production costs are lowest. As progressively higher levels of production are required, the model extends corn production into areas where production costs per unit of yield

are progressively higher. It adjusts production patterns to reflect where the 11 major crops can be most cheaply grown and chooses the most efficient use of such factors as fertilizers, land, water, and conservation measures.

The model also accounts for the effects of erosion on crop yields. Initially, a large number of different activities are specified, from which the model can select the means for meeting the total agricultural production goals. Each activity is accompanied by a cost, an erosion rate, and a resulting yield level. The model then selects the least costly means of producing the required output. When the required output is small, the model can select relatively more of the activities that have low costs, are located on soils that have low inherent erosion rates, and therefore experience low yield reduction caused by erosion.

As the required production is increased, however, the model is forced to select more activities on lands that are inherently more erodible in order to satisfy the production objective. Because the yields associated with these activities are lower if no conservation practices are used, the model must begin to choose between (1) more land with a higher erosion rate and (2) fewer acres that have conservation practices installed (and therefore higher costs) but that retain their long term productivity.

Therefore, as demand increases, the model increasingly selects activities where conservation measures are applied. This, however, requires that the farmer recover the cost of the conservation measures over a 50-year period. Further, it requires the assumption that farmers have a 50-year planning horizon. Since such an assumption may be unrealistic, the results of the various model solutions should be carefully interpreted. Although they show that some soil and water conservation practices are cost effective and necessary from a social viewpoint, it is unlikely that many farmers would adopt them without assistance or incentives. The effect of planning horizons on the farmer's perception of costs is discussed later in this section.

The model also assumes that economic adjustments can be made instantly. In reality, of course, instantaneous adjustments are not possible. Regional shifts in production or in any large scale economic activity occur gradually. Therefore, for RCA analyses, the model was constrained to recognize these realities.

For the year 2000, the model was not permitted to reduce the acreage of any crop in any producing area by more than 10 percent from the 1977 base acreages. For the year 2030, it was not permitted to reduce the acreage of any crop in an area by more than 30 percent. No limit was placed on increases in crop acreages because the 20- to 50-year period should allow adequate time for such increases.

Alternative Export Levels.--The model analyzed the effects of achieving various levels of production. Table 3A-5 shows the effects on the cropland resource base of meeting the three alternative levels of exports in an "unconstrained future." The "unconstrained future," or "economic optimum" solution, is the solution that the model selects as the least costly array of cropping and treatment alternatives that will satisfy the demands imposed upon the model subject to such constraints as limited shifts in crop acreage, availability of resources, and the effects of erosion on productivity. The

Table 3A-5.--Model projections of conditions required to meet alternative export levels in 2000 and 2030 (unconstrained future)

Indicator	Unit of measure	Domestic demand only 2000	Domestic demand only 2030	1975-77 export level plus domestic demand 2000	1975-77 export level plus domestic demand 2030	Projected export level plus domestic demand 2000	Projected export level plus domestic demand 2030
Real cost of Food and Fiber Production	Index 1/	83	67	128	100	202	258
Average crop yield:							
Corn	bu/acre	104.63	132.65	106.94	136.28	107.29	143.67
Wheat	bu/acre	31.90	41.00	34.85	41.72	35.45	42.26
Soybeans	bu/acre	36.39	47.19	36.23	46.32	35.64	44.50
Cotton	bales/acre	1.00	1.44	1.01	1.49	1.10	1.42
Sorghum	bu/acre	50.86	58.82	52.84	61.27	56.70	67.01
Legume (hay)	tons/acre	3.14	3.86	3.19	3.86	3.24	3.85
Shadow price:							
Corn	$/bu	1.04	0.84	1.21	0.95	1.73	1.96
Wheat	$/bu	1.56	1.29	1.97	1.61	3.15	4.26
Oilmeals	$/cwt	1.71	3.30	5.03	4.09	7.91	10.06
Cotton	$/bale	133.32	119.88	143.51	122.48	166.98	185.87
Sorghum	$/bu	1.42	1.25	1.58	1.33	2.32	3.02
Legume (hay)	$/ton	36.08	27.37	33.68	29.71	45.98	60.98
Sheet and rill erosion:							
Cropland (all uses)	million tons	990	922	1,488	1,240	1,548	1,263
Average number of acres with erosion greater than--							
5 tons per acre per year	1,000 acres	105,380	80,281	64,343	39,045	84,483	49,486
10 tons per acre per year	1,000 acres	30,929	21,792	18,907	17,032	17,222	16,391

Table 3A-5.--Model projections of conditions required to meet alternative export levels, in 2000 and 2030 (unconstrained future)--Continued

Indicator	Unit of measure	Domestic demand only		1975-77 export level plus domestic demand		Projected export level plus domestic demand	
		2000	2030	2000	2030	2000	2030
Cropland use:	1000 acres						
Dry cropland		214,468	223,736	325,046	290,767	340,290	337,615
Irrigated cropland		9,021	8,354	14,400	13,665	22,388	27,721
Exogenous cropland 2/		23,177	23,544	23,177	23,544	23,177	23,544
Converted to dry cropland 3/		(530)	(297)	(1,505)	(1,955)	(10,444)	(18,132)
Total cropland use		246,666	255,931	362,623	327,976	385,855	388,880
Chemicals used:							
Fertilizer	million $	5,206	5,201	7,404	6,893	8,354	8,489
Nitrogen	1,000 tons	7,386	7,082	10,108	9,322	11,532	11,456
Pesticides and herbicides	million $	3,971	3,723	7,041	5,715	10,668	11,762
Conservation treatment:	1,000 acres						
Conservation tillage (M) 4/		99,140	93,119	156,642	132,304	160,785	152,854
Conservation tillage (H) 5/		101,370	115,641	148,469	148,225	162,767	174,513
Contoured		0	0	0	0	0	1,494
Stripcropped		0	1,009	236	1,239	236	6,747
Terraced		91	1,240	586	6,034	39	13,571

1/ Based on 1975-77 export level, where yields for 2030 equal 100. It includes the cost of production for all commodities consumed domestically and exported.

2/ Exogenous cropland is the land required for the production of specialty crops not included in the model.

3/ Acreage is included in "Dry cropland."

4/ Generally spring plowing, residues not removed; a moderate level of conservation tillage.

5/ Minimum tillage or a high level of conservation tillage.

model selects soil conserving activities and practices only if they are the least costly means of meeting total national demand for agricultural products.

For each of these export levels, please note again that projections are relative, not absolute. Table 3A-6 shows projections of cropland needs under all three export levels.

- Domestic Needs Only (No Exports).--If domestic needs were met and no agricultural commodities were exported, fewer resources would be used in 2000 or 2030 than are now devoted to agricultural production. Little effort would be needed to maintain the cropland resource base at a level that would meet demand. Production costs, as reflected by shadow prices, would be low. Only 256 million acres would be needed for agricultural production, and the cropland reserve would be more than 109 million acres.

  (A shadow price is defined as the marginal cost of the last unit needed to meet a specific level of demand. It includes the market price of annually purchased supplies, such as seed and fertilizer, plus an implied cost that reflects the relative scarcity of land and other resources not purchased annually.)

  The level of conservation treatment on cropland that is reflected in table 3A-5 could be less than at present, representing a disinvestment in conservation, and still meet projected demand. In summary, there appears to be no problem with the capacity of the resource base to meet only the domestic demand through at least 2030.

  The cost of production index and the shadow prices are lower for 2030 than for 2000. This seemingly odd result occurs because the development and adoption of technology with the resultant increases in crop yields have the effect of increasing potential output more rapidly than demand increases due to domestic population increase and improving levels of income.

- Domestic Needs Plus 1975-77 Export Level.--If domestic needs were met and exports continued at the 1975-77 level, the pressure on the resource base would remain at about the level of the mid to late 1970's. No more cropland would be needed through 2030. The increase in domestic demand between 1980 and 2030 could largely be met through increases in yield resulting from new technology if current levels of soil and water conservation continue. The amount of cropland needed to produce this demand level would require about 72 million more acres than for the no export situation. Thirty-seven million acres of cropland would remain in reserve, however, so the cost of production as reflected by the shadow prices would not increase significantly.

- Domestic Needs Plus Projected Exports.--If the projected export demand plus domestic needs were met, significant pressures would be exerted on the Nation's resources. Production costs, and therefore prices for agricultural commodities, would probably increase. By 2030, the cost of production would probably be about 285 percent greater than the cost of production for domestic needs only and about 158 percent greater than

Table 3A-6.--Analysis of the agricultural land base in 2030 (unconstrained future)

Item	Cropland available			Projected cropland harvested	Excess or deficit 2/	Potential for conversion 3/	Buffer
	Existing 1977	Lost to other uses	Total available				
	(Millions of acres)						
1977 Actual 1/	413	---	413	343	---	135	135
Projected production levels in 2030:							
Domestic consumption only	413	48	365	256	109	135	244
Domestic plus base exports	413	48	365	328	37	135	172
Domestic plus projected exports	413	48	365	389	-24	135	111

1/ Data from the NRI (USDA, 1978b) and Agricultural Statistics (USDA, 1978a).

2/ Indicates changes in acreage from the amount of land not cultivated, adjusted for losses to other uses.

3/ Includes land now used for pasture, forest, or range but that has high or medium potential for conversion to cropland.

the costs for domestic demand plus the 1975-77 export levels. An expanded conservation program would be needed to maintain the productivity of the soil. About 24 million acres of land not currently used as cropland would have to be converted to crop production to meet this level of demand.

Opportunities to Resolve Resource Problems

Maintenance of Productivity Through Erosion Control on Cropland.--Tables 3A-7 through 3A-10 show the effects of achieving various levels of erosion reduction on cropland. In these tables, the reduction in erosion is expressed as a percentage of reduction from the "unconstrained future," which the model estimates for each of the 105 producing areas. Within each producing area, some land can be eroding at very high rates as long as the gross erosion within that producing area meets the erosion reduction constraint required by the model.

Tables 3A-7 and 3A-8 project conditions for 2000 and 2030 if production is sufficient only for domestic needs and for exports at the 1975-77 level. Under these conditions, the greatest pressures on cropland are likely to be exerted between 1980 and 2000. By 2030, the increase in crop yields resulting from new developments in agricultural technology is projected to be greater than the projected increase in domestic demand resulting from increases in population and real income. The effects of erosion control will begin to have much more influence on crop yields between 2000 and 2030.

The change in cost of food production necessary to attain a given level of erosion reduction is higher for the 20 year planning horizon than for the 50 year horizon. For example, the cost of food production in 2000 while achieving a 30 percent reduction in erosion is 89 percent greater than the cost projected for the unconstrained future. Achieving the same erosion reduction rate by the year 2030 increases the cost of food production by only 12 percent. Also note that the unconstrained future for 2030 shows erosion levels on cropland to be about 1.24 billion tons, whereas the unconstrained future for 2000 shows a gross sheet and rill erosion level of about 1.49 billion tons annually. Higher levels of erosion reduction are more cost effective in maintaining productivity over the longer period because the effect of erosion on yields is cumulative over time. Also, at the relatively low demand level, farming more land and increasing the use of fertilizers and pesticides is cheaper than installing conservation practices, particularly in the relatively short time between now and 2000.

The pressures on soil resources and the cost effectiveness of installing soil conservation measures to maintain productivity increase dramatically at the production level needed to meet domestic demand plus the projected export level (tables 3A-9 and 3A-10). For example, reducing erosion uniformly in all producing areas by 40 percent failed to change the cost of food and fiber production for the projected export level, while reducing erosion by 30 percent increased food and fiber costs by 4 percent at the 1975-77 level of exports. This indicates that in the case of high demand, when the costs of the added production must be borne, the specified level of erosion can be attained by using either an extensive acreage of low yielding land or lesser amounts of more productive land that is protected by conservation practices. Under both approaches, the per unit costs of production tend to be equally

Table 3A-7.--Model projections of conditions in 2000 for alternative levels of reduction in soil erosion (1975-77 export level)

Indicator	Unit of measure	Unconstrained future 1/	30 percent reduction in erosion 1/	60 percent reduction in erosion 1/
Real cost of food and fiber production	Index 2/	128	141	242
Increase over unconstrained future	Percent	---	10	89
Average crop yield:				
Corn	bu/acre	106.9	107.69	107.05
Wheat	bu/acre	34.8	34.79	35.09
Soybeans	bu/acre	36.2	36.30	36.07
Cotton	bales/acre	1.01	0.99	0.98
Sorghum	bu/acre	52.8	53.28	55.01
Legume (hay)	tons/acre	3.19	3.21	3.22
Shadow price:				
Corn	$/bu	1.21	1.25	1.35
Wheat	$/bu	1.97	2.11	2.49
Oilmeals	$/cwt	5.03	5.37	5.87
Cotton	$/bale	143.51	225.02	186.38
Sorghum	$/bu	1.58	1.76	2.84
Legume (hay)	$/ton	33.68	46.64	273.35
Sheet and rill erosion:				
Cropland (all uses)	million tons	1,488	1,035	593
Average number of acres with erosion greater than--				
5 tons per acre per year	1,000 acres	63,343	40,967	5,406
10 tons per acre per year	1,000 acres	18,907	4,764	2,084

Table 3A-7.--Model projections of conditions in 2000 for alternative levels of reduction in soil erosion (1975-77 export level)--Continued

Indicator	Unit of measure	Unconstrained future 1/	30 percent reduction in erosion 1/	60 percent reduction in erosion 1/
Cropland use estimates:	1,000 acres			
Dry cropland		325,046	321,285	320,171
Irrigated cropland		14,400	16,409	18,168
Exogenous cropland 3/		23,177	23,177	23,177
Converted to dry cropland 4/		(1,505)	(1,531)	(3,843)
Total cropland use		362,623	360,871	361,516
Cnange in cropland use:				
105 producing areas				
Total gains	1,000 acres	----	2,780	12,987
Total losses	1,000 acres	----	4,737	9,289
Chemicals used:				
Fertilizer	million $	7,404	7,350	7,492
Nitrogen	1,000 tons	10,108	10,077	10,239
Pesticides and herbicides	million $	7,041	7,535	8,655
Conservation treatment	1,000 acres			
Conservation tillage (M) 5/		156,642	141,433	129,296
Conservation tillage (H) 6/		148,469	163,345	177,760
Contoured		0	20,490	86,270
Stripcropped		236	6,985	15,314
Terraced		586	8,011	34,175

1/ All erosion reduction levels are expressed as a percentage of the "unconstrained future" level.
2/ Based on 1975-77 export level, where yields for 2030 equal 100. It includes the cost of production for all commodities consumed domestically and exported.
3/ Exogenous cropland is the land required for the production of specialty crops not included in the model.
4/ Acreage is included in "Dry cropland".
5/ Generally spring plowing, residues not removed; a moderate level of conservation tillage.
6/ Minimum tillage or a high level of conservation tillage.

Table 3A-8.--Model projections of conditions in 2030 for alternative levels of reduction in soil erosion (1975-77 export level)

Indicator	Unit of measure	1977 erosion rate 1/	Unconstrained future 2/	30 percent reduction in erosion 2/	60 percent reduction in erosion 2/
Real cost of food and fiber production	Index 3/	109	100	104	112
Increase over unconstrained future	Percent	9	---	4	12
Average crop yield:					
Corn	bu/acre	135.59	136.28	135.72	135.72
Wheat	bu/acre	40.96	41.72	41.90	42.28
Soybeans	bu/acre	45.34	46.32	46.34	46.27
Cotton	bales/acre	1.47	1.49	1.53	1.48
Sorghum	bu/acre	60.66	61.27	61.43	61.62
Legume (hay)	tons/acre	3.78	3.86	3.82	3.90
Shadow price:					
Corn	$/bu	0.96	0.95	0.96	1.11
Wheat	$/bu	1.61	1.61	1.83	1.88
Oilmeals	$/cwt	4.21	4.09	4.24	4.51
Cotton	$/bale	121.87	122.48	122.87	134.17
Sorghum	$/bu	1.35	1.33	1.38	1.46
Legume (hay)	$/ton	57.30	29.71	29.43	29.75
Sheet and rill erosion:					
Cropland (all uses)	million tons	1,886	1,240	874	502
Average number of acres with erosion greater than--					
5 tons per acre per year	1,000 acres	80,346	39,045	22,958	4,515
10 tons per acre per year	1,000 acres	30,796	17,032	2,630	0

Table 3A-8.--Model projections of conditions in 2030 for alternative levels of reduction in soil erosion (1975-77 export level)--Continued

Indicator	Unit of measure	1977 erosion rate 1/	Unconstrained future 2/	30 percent reduction in erosion 2/	60 percent reduction in erosion 2/
Cropland use estimates:	1,000 acres				
Dry cropland		306,308	290,767	299,583	297,478
Irrigated cropland		13,188	13,665	13,409	13,168
Exogenous cropland 4/		23,177	23,177	23,177	23,177
Converted to dry cropland 5/		(2,682)	(1,955)	(1,531)	(3,843)
Total Cropland Use		342,673	327,609	336,169	333,823
Change in cropland use: 105 producing areas					
Total gains	1,000 acres	12,189	----	6,318	9,721
Total losses	1,000 acres	7,072	----	6,853	12,664
Chemicals used:					
Fertilizer	million $	7,054	6,893	6,893	6,924
Nitrogen	1,000 tons	9,485	9,322	9,315	9,327
Pesticides and herbicides	million $	6,591	5,715	6,094	7,558

Table 3A-8.--Model projections of conditions in 2030 for alternative levels of reduction in soil erosion (1975-77 export level)--Continued

Indicator	Unit of measure	1977 erosion rate 1/	Unconstrained future 2/	30 percent reduction in erosion 2/	60 percent reduction in erosion 2/
Conservation treatment:	1000 acres				
Conservation tillage (M) 6/		173,631	132,304	121,119	109,290
Conservation tillage (H) 7/		93,088	148,225	160,521	172,883
Contoured		8,371	0	19,142	95,791
Stripcropped		1,076	1,239	5,758	13,876
Terraced		14,394	6,034	14,898	31,353

1/ For this solution, the model was constrained to produce at least the quantity of erosion that occurred in each producing area in 1977.

2/ All erosion reduction levels are expressed as a percentage of the "unconstrained future" level.

3/ Based on 1975-77 export level, where yields for 2030 equal 100. It includes the cost of production for all commodities consumed domestically and exported.

4/ Exogenous cropland is the land required for the production of specialty crops not included in the model.

5/ Acreage is included in "Dry cropland".

6/ Generally spring plowing, residues not removed; a moderate level of conservation tillage.

7/ Minimum tillage or a high level of conservation tillage.

Table 3A-9.--Model projections of conditions in 2000 for alternative levels of reduction in soil erosion (projected export level)

Indicator	Unit of measure	Unconstrained future 1/	20 percent reduction in erosion 1/	30 percent reduction in erosion 1/	40 pecent reduction in erosion 1/
Real cost of food and fiber production	Index 2/	202	204	204	206
Increase over unconstrained future	Percent	---	1	1	2
Average crop yield:					
Corn	bu/acre	107.29	108.07	108.51	108.54
Wheat	bu/acre	35.45	35.02	34.97	35.02
Soybeans	bu/acre	35.64	35.67	35.61	35.64
Cotton	bales/acre	1.10	0.99	0.99	1.11
Sorghum	bu/acre	56.70	57.05	57.18	57.11
Legume (hay)	tons/acre	3.24	3.25	3.24	3.25
Shadow price:					
Corn	$/bu	1.73	1.74	1.75	1.77
Wheat	$/bu	3.15	3.43	3.43	3.47
Oilmeals	$/cwt	7.91	7.94	7.99	8.13
Cotton	$/bale	166.98	170.47	73.31	173.83
Sorghum	$/bu	2.32	2.34	2.35	2:50
Legume (hay)	$/ton	45.98	44.76	44.81	44.95
Sheet and rill erosion:					
Cropland (all uses)	million tons	1,548	1,242	1,093	935
Average number of acres with erosion greater than--					
5 tons per acre per year	1,000 acres	84,483	78,617	74,097	40,601
10 tons per acre per year	1,000 acres	17,222	3,647	3,667	0

Table 3A-9.--Model projections of conditions in 2000 for alternative levels of reduction in soil erosion (projected export level)--Continued

Indicator	Unit of measure	Unconstrained future 1/	20 percent reduction in erosion 1/	30 percent reduction in erosion 1/	40 pecent reduction in erosion 1/
Cropland use estimates:	1,000 acres				
Dry cropland		340,290	340,580	340,477	341,286
Irrigated cropland		22,388	22,311	22,284	22,500
Exogenous cropland 3/		23,177	23,177	23,177	23,177
Converted to dry cropland 4/		(10,444)	(10,444)	(10,444)	(10,534)
Total cropland use		385,855	386,068	385,938	386,963
Change in cropland use	1000 acres				
Total gains		----	1,580	1,875	2,677
Total losses		----	1,694	2,227	3,693
Chemicals used:					
Fertilizer	million $	8,354	8,321	8,297	8,302
Nitrogen	1,000 tons	11,532	11,504	11,452	11,453
Pesticides	million $	10,668	11,544	12,187	11,836

Table 3A-9.--Model projections of conditions in 2000 for alternative levels of reduction in soil erosion (projected export level)--Continued

Indicator	Unit of measure	Unconstrained future 1/	20 percent reduction in erosion 1/	30 percent reduction in erosion 1/	40 pecent reduction in erosion 1/
Conservation treatment:	1000 acres				
Conservation tillage (M) 5/		160,785	148,281	138,827	131,372
Conservation tillage (H) 6/		162,767	178,392	188,515	195,363
Contoured		0	17,412	53,747	91,748
Stripcropped		236	6,307	9,455	13,921
Terraced		39	1,263	2,731	4,262

1/ All erosion reduction levels are expressed as a percentage of the "unconstrained future" level. Projected export levels for 2000 include a 30 percent reduction in erosion. This 30 percent reduction was not projected for 2030. Projections for 2030, however, include a 60 percent reduction in erosion.

2/ Based on 1975-77 export level, where yields for 2030 equal 100. It includes the cost of production for all commodities consumed domestically and exported.

3/ Exogenous cropland is the land required for the production of specialty crops not included in the model.

4/ Acreage included in "Dry cropland."

5/ Generally spring plowing, residues not removed; a moderate level of conservation tillage.

6/ Minimum tillage or a high level of conservation tillage.

Table 3A-10.--Model projections of conditions in 2030 for alternative levels of reductions in soil erosion (projected export level)

Indicator	Unit of measure	1977 erosion rate 1/	Un-constrained future 2/	20 percent reduction in erosion 2/	40 percent reduction in erosion 2/	60 percent reduction in erosion 2/
Real cost of food and fiber production	Index 3/	512	258	260	258	297
Increase over unconstrained future	Percent	98	---	1	---	15
Average crop yield:						
Corn	bu/acre	142.72	143.67	143.80	143.95	143.58
Wheat	bu/acre	43.36	42.26	42.61	42.63	43.07
Soybeans	bu/acre	43.73	44.50	44.52	44.57	44.28
Cotton	bales/acre	1.43	1.42	1.42	1.43	1.44
Sorghum	bu/acre	68.99	67.01	67.11	67.16	68.23
Legume (hay)	tons/acre	3.79	3.85	3.86	3.86	3.79
Shadow Price:						
Corn	$/bu	3.55	1.96	1.98	1.95	2.29
Wheat	$/bu	8.58	4.26	4.40	4.47	5.14
Oilmeals	$/cwt	19.59	10.06	10.12	10.08	12.13
Cotton	$/bale	290.11	185.87	187.78	188.76	210.45
Sorghum	$/bu	5.73	3.02	3.04	3.04	3.65
Legume (hay)	$/ton	154.85	60.98	60.22	59.19	52.37
Sheet and rill erosion:						
Cropland (all uses)	million tons	1,866	1,263	1,012	762	511
Average number of acres with erosion greater than:						
5 tons per acre per yr.	1,000 acres	76,766	49,486	4,218	7,751	5,580
10 tons per acre per yr.	1,000 acres	23,229	16,391	3,783	186	0

Table 3A-10.--Model projections of conditions in 2030 for alternative levels of reductions in soil erosion (projected export level)--Continued

Indicator	Unit of measure	1977 erosion rate 1/	Un-constrained Future	20 percent reduction in erosion 2/	40 percent reduction in erosion 2/	60 percent reduction in erosion 2/
Cropland use estimates:	1,000 acres					
Dry cropland		347,424	337,615	339,024	339,249	336,311
Irrigated cropland		40,882	27,721	30,771	27,742	30,209
Exogenous use 4/		23,544	23,544	23,544	23,544	23,544
Converted to dry cropland 5/		(22,776)	(18,132)	(19,190)	(17,713)	(16,185)
Total cropland use		411,850	388,880	393,339	390,535	390,064
Change in cropland use:						
105 producting areas						
Total gains	1,000 acres	4,301	----	598	1,037	1,909
Total losses	1,000 acres	4,941	----	887	1,562	3,776
Chemicals used:						
Fertilizer	million $	8,712	9,489	8,493	8,493	8,624
Nitrogen	1,000 tons	11,679	11,456	11,448	11,420	11,538
Pesticides and herbicides	million $	13,495	11,762	14,107	15,487	17,285

Table 3A-10.--Model projections of conditions in 2030 for alternative levels of reductions in soil erosion (projected export level)--Continued

Indicator	Unit of measure	1977 erosion rate 1/	Un-constrained future 2/	20 percent reduction in erosion 2/	40 percent reduction in erosion 2/	60 percent reduction in erosion 2/
Conservation treatment:	1000 acres					
Conservation tillage (M) 6/		187,645	152,854	149,938	131,307	110,772
Conservation tillage (H) 7/		111,699	174,513	187,790	197,636	217,406
Contoured		6,041	1,494	28,808	76,856	124,511
Stripcropped		5,483	6,747	12,114	17,269	11,454
Terraced		18,430	13,571	20,188	32,178	57,217

1/ For this solution, the model was constrained to produce at least the quantity of erosion that occurred in each producing area in 1977.

2/ All erosion reduction levels are expressed as a percentage of the "unconstrained future" level. Projected export levels for 2030 include a 60 percent reduction in erosion. This 60 percent reduction was not projected for 2000. Projections for 2000, however, include a 30 percent reduction in erosion.

3/ Based on 1975-77 export level, where yields for 2030 equal 100. It includes the cost of production for all commodities consumed domestically and exported.

4/ Exogenous cropland is the land required for the production of specialty crops not included in the model.

5/ Acreage is included in "Dry cropland."

6/ Generally spring plowing, residues not removed; a moderate level of conservation tillage.

7/ Minimum tillage or a high level of conservation tillage.

high. In the case of lower demand, the added cost of attaining the specified level of erosion is simply an add-on cost that would not otherwise have been incurred.

In order to determine the impact on future potential productivity if current levels of erosion are continued, USDA analyzed the situation if domestic demand plus projected export levels were met and the model was required to produce the current level of erosion. The results are shown in table 3A-10 for comparison with the unconstrained future and with erosion reductions of 20, 40, and 60 percent. If the current levels of erosion were allowed to continue over the next 50 years, erosion would cause a loss in productive capacity equivalent to the loss of 23 million acres of cropland, almost half the loss expected because of competing demands, such as urban development. This loss of productivity would cause the costs of food and fiber to be nearly double those under the unconstrained future. In addition, the acreage of cropland with erosion of more than 5 tons per acre per year would be over 34 million acres greater than for the unconstrained future.

Reducing erosion by 60 percent from the unconstrained future level results in annual erosion of only about 0.5 billion tons annually. Reducing erosion on cropland from the present level of about 2 billion tons annually to about 0.5 billion tons annually (75 percent reduction) would require a significant change in the use and mix of management practices. For example, the amount of chemical herbicides and pesticides that the model predicted would be used increased about 28 percent over the amount needed at the 1977 erosion rate and was 47 percent more than the unconstrained solution. More chemicals would be used because reduced tillage would be used more. See table 3A-10.

Soil losses now exceed 5 tons per acre per year on about 97 million acres of cropland (USDA, 1978b). A reduction to 0.5 billion tons per year nationally would leave only about 5.6 million acres eroding at a rate greater than 5 tons annually.

The tables show that generally the most cost effective way of reducing erosion is through the use of conservation tillage and contouring. The model uses these measures first if it is asked to provide for erosion reduction. The model projects the use of more expensive measures, such as stripcropping and terracing, only when less expensive measures will not achieve the level of erosion reduction requested.

The costs of achieving various levels of reduction in erosion are reflected in the shadow prices (marginal cost) of production given in the tables. For example, in table 3A-10 the shadow price of producing a bushel of corn shows relatively little change if erosion is reduced 40 percent but increases by $0.33 if erosion is reduced 60 percent. The shadow price of producing a bushel of wheat increases only from $4.26 to $4.47 if erosion is reduced 40 percent but increases to $5.14 if erosion is reduced 60 percent. The tables show that the costs of reducing erosion by about 40 to 50 percent below the unconstrained future are relatively low. The costs increase rapidly, however, if erosion is further reduced. The results of this analysis correspond closely to those of a study done in Texas (Renau and Taylor, 1979) and to other studies (see figure 3A-2).

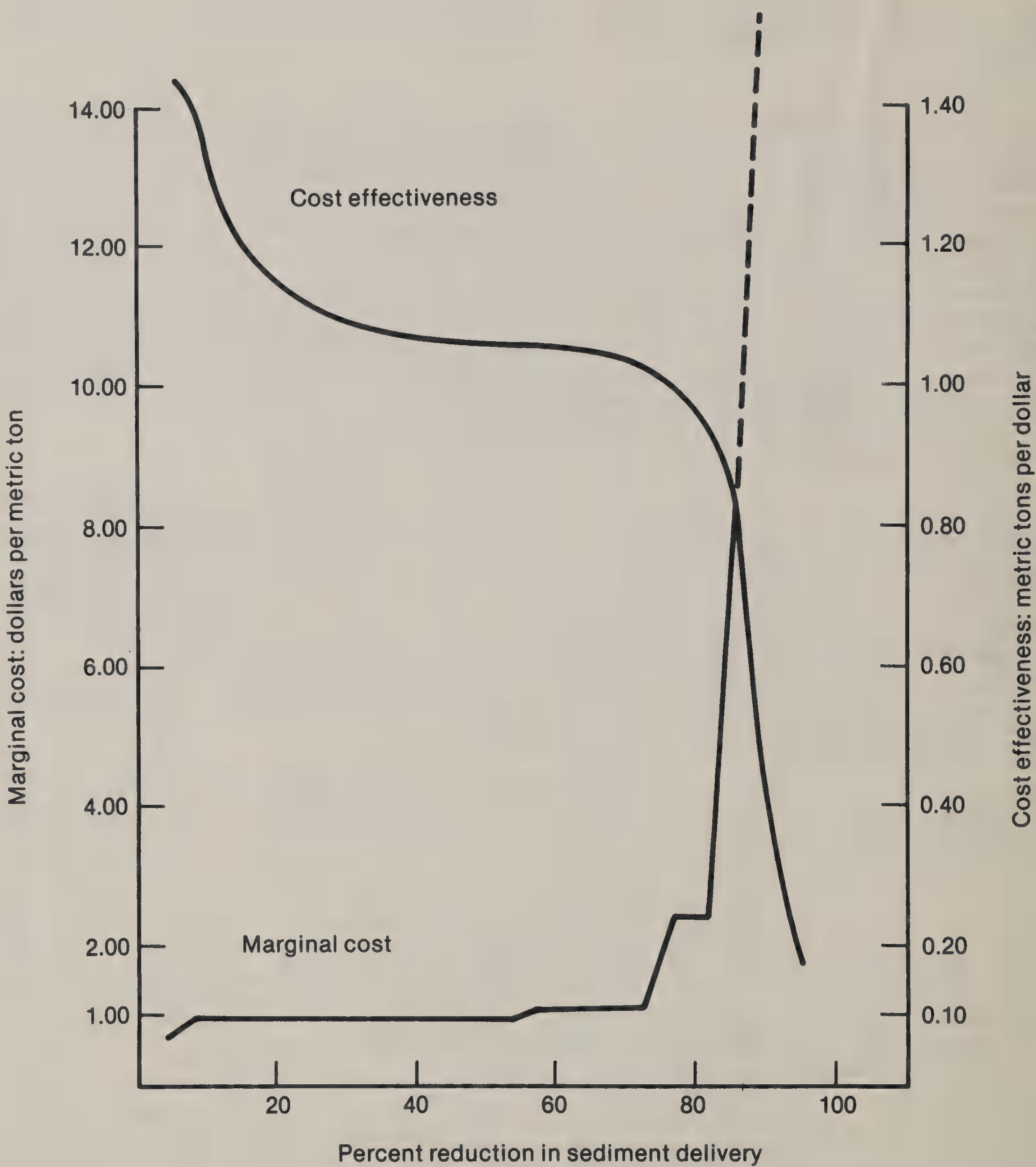


Figure 3A-2.--Cost effectiveness and marginal cost for reducing sediment delivery on a Texas example farm, 1979. (Renau and Taylor, 1979)

The fact that the level of erosion in the unconstrained future is significantly lower for 2000 and 2030 than it would be if present erosion rates continue indicates that it is in the economic interest of society to undertake erosion control programs. However, those actions that make economic sense to society over a 50-year time period often are quite different from those that make sense to a land user who takes a much shorter view. Many land users are reluctant to undertake investments with a payment period longer than 5 to 10 years. Because a 5- to 10-year planning horizon is more realistic to the land user, some public investment is likely to be necessary to implement practices that have payback periods of more than 10 years.

The following example illustrates the loss of value of productivity caused by erosion and sets the stage for a consideration of personal versus social discount rates and planning horizons. USDA analyzed data from more than 1,100 published soil surveys and found that the potential decline in yields of corn is about 3 bushels per inch of topsoil lost. In table 3A-11, USDA made the following assumptions: the soil is subjected to an average erosion rate of 15 tons per acre per year; corn has a value of $2.00 per bushel; in its uneroded state, the soil is deep and has a potential yield of 143 bushels per acre; and a soil loss of 15 tons per acre per year amounts to 1 inch of erosion in 10 years. These assumptions reflect typical conditions throughout the Corn Belt. In the example, the cumulative loss in productivity is 375 bushels of corn. At $2.00 per bushel, the reduced yield costs the farmer $750 per acre over the 50 years. Since 50 years of erosion at 15 tons per acre per year means that 750 tons of soil are lost from each acre over the period, the undiscounted average annual loss to the farmer is only $1 per ton, or $15 per year.

Table 3A-11.--Effect of erosion on cumulative corn production over 50 years

	Number of years over which erosion continues					
	0	10	20	30	40	50
	(Bushels)					
Per acre yield at start of period.	143	140	137	134	131	128
Production lost due to erosion which occurred during:						
1st 10 year period		15	30	30	30	30
2nd 10 year period			15	30	30	30
3rd 10 year period				15	30	30
4th 10 year period					15	30
5th 10 year period						15
Cumulative production lost for each 10 year period.		15	45	75	105	135

It should first be noted that the annual loss of corn production is quite small relative to the amount produced, that it occurs mostly in the future, and that it can be masked by a much greater annual variation in yields due to weather. Given these factors, it is not surprising that a farmer may view erosion control as not worthy of a significant investment.

Table 3A-12 and 3A-13 show how discounting and planning horizons affect the perception of the value of soil productivity loss due to erosion. For example, if society has a 50 year planning horizon and a discount rate of 4 percent, the average annual value of production lost because of the loss of a ton of soil is $0.71. In contrast, a farmer who has a planning horizon of 10 years and a 15 percent discount rate perceives the loss to be equivalent to about $0.18. The difference between these two values ($0.53 per ton) could be considered to be the minimum amount that society as a whole must pay if voluntary erosion control is to work.

Improving Deteriorated Range Condition and Grazing Management.--Rangeland in poor or fair condition is usually the result of years of overuse or of abnormal and severe disturbances, such as drought. USDA estimates show considerable recent improvement in range condition. See chapter 3, section C, of Part I of the 1980 RCA Appraisal for details.

Range condition reflects the present plant community of a range site as related to the potential plant community for that site. Although it does not automatically indicate the value of a plant community for livestock production, there is usually a high degree of correlation between range condition and the overall health of the range. A site in good or excellent condition produces more forage than one in fair or poor condition.

McCorkle and Heerwagen (1951) made a survey of representative commercial cattle ranches in the Great Plains section of Colorado and New Mexico to determine the influence of range condition on livestock production. Ranches having average good range condition marketed 14.3 pounds of cattle per acre, those having average fair condition, 11.2 pounds per acre, and those having average poor condition, 8.9 pounds per acre (table 3A-14).

Reducing Brush and Weed Competition.--The 1973 SCS rangeland survey (Bredemieir, 1973) showed that dense brush infests 91.5 million acres, or 22 percent of the nonfederal rangeland in the United States. Unwanted brush and weeds significantly reduce the productivity of range. For example, mesquite grows on about 93 million acres in the Southwest, and it reduces the overall yield of range products by an estimated 30 percent (USDA and EPA, 1979). Cable and Martin (1975) found in Arizona that controlling mesquite increased the growth of perennial grass by 52 percent. Similar results have been reported following control of juniper, oak species, and sagebrush (Aro, 1971).

Research and Technology Development.--The rate of development of technology will significantly determine the capability of the Nation's agricultural land to meet future demands for food and fiber. Production of the four most extensively grown field crops (corn, wheat, soybeans, and sorghum) in the United States increased 82 percent between 1959 and 1978. This was accomplished partly by increasing the harvested acreage of these crops by 29 percent, or 47 million acres. During this period, however, average yields

Table 3A-12.--Discounted value of production loss for a 50 year planning horizon

Interest rate	50-year amortization factor	Present value of increment annuity	Annual increment	Average annual value of loss-- Per acre	Per ton
0	0.020	1250.0	0.60	15.00	$1.00
4	0.097	382.6	0.60	10.69	0.71
7	0.072	186.7	0.60	8.07	0.54
10	0.100	104.8	0.60	6.29	0.42
12	0.120	76.1	0.60	5.48	0.37
15	0.150	50.8	0.60	4.57	0.30

Table 3A-13.--Discounted value of production loss for a 10 year planning horizon

Interest rate	10-year amortization factor	Present value of increment annuity	Annual increment	Average annual value of loss-- Per acre	Per ton
0	0.100	250.0	0.60	15.00	1.000
4	0.123	41.992	0.60	3.10	0.207
7	0.142	34.739	0.60	2.96	0.197
10	0.163	29.036	0.60	2.84	0.189
12	0.177	25.904	0.60	2.75	0.183
15	0.199	21.998	0.60	2.63	0.175

Table 3A-14.--Range condition and beef production on selected breeding cow ranches in Colorado and New Mexico, 1951

Ranch	Average range condition	Type of operation	Stocking rate per AUM	Average production per acre
			(Acres)	(Pounds)
1	Good	Cow-calf-yearling; some steers purchased	3.5	15.1
2	Good	Cow-calf	2.2	12.2
3	Good	Cow-calf-yearling; some steers purchased	2.7	16.0
4	Good	Cow-calf-yearling	2.9	17.5
5	Good	Cow-calf-yearling	2.1	17.6
Weighted averages			2.8	14.3
6	Fair	Cow-calf-yearling	2.6	9.7
7	Fair	Cow-calf-yearling	3.1	12.0
8	Fair	Cow-calf; some yearling	3.7	9.5
9	Fair	Cow-calf; some yearling	3.6	10.1
10	Fair	Cow-calf-yearling; some steers purchased	2.7	11.1
Weighted averages			3.1	11.2
11	Poor	Cow-calf	3.2	5.8
12	Poor	Cow-calf-yearling	2.7	11.3
Weighted average			2.9	8.9
Weighted average all ranches			3.0	11.9

Source: McCorkle and Heerwagen, 1951.

for these crops increased by 42 percent (USDA, 1979). Better methods of improving soil fertility undoubtedly helped achieve this record. Yields increased steadily through the 1960's, a period when the acreage under cultivation did not increase. Between 1970 and 1977, the harvested acreage of these four major crops increased by 51 million acres, and with the exception of wheat, yields have continued to increase.

Even if average crop yields increase about 50 percent by the year 2030, there will still be heavy pressure on the Nation's soil and water resources if it attempts to satisfy any significant level of export demand. In order to realize this increase in yields, it will be necessary to develop technology at the rate of 1 percent or more per year. Such development will require a vigorous and highly directed research effort. Among the areas to which this research should be directed are:

- Soil testing and interpretation.--Soil tests and the ability to predict the results of these tests must continue to be improved so crops can efficiently use fertilizer and so pollution of surface and ground waters can be prevented. Continued research is needed to determine how to adjust soil test recommendations to the different management factors applicable on thousands of kinds of soil. This requires commitment to continuous, long-term field experiments on key soil types to provide the needed data base. Soil test interpretations are no better than the field experiments on which they are based.

- Soil moisture.--A better understanding of soil moisture relationship is critical to more efficient management of our soil and water resources. Among the areas that must be explored are:
    1. Soil moisture information that is accurate and applicable over an identifiable general area (producing area, for example).
    2. Response of specific crops to soil moisture stress at critical times during crop growth.
    3. Response to moisture stress of specific crops that are drought resistant or that have high regenerative abilities, and are important economically (soybeans, for example).
    4. Soil moisture movement in unsaturated conditions in the soil matrix over areas the size of several counties.
    5. Water budgeting techniques that accurately display what is occurring below the soil-air interface. Remote sensing will soon provide good information on soil moisture at the interface. However, sampling stations and budgeting are needed to accurately portray soil moisture conditions below that interface.

- Genetics and physiology.--Genetics determine a crop's potential, and the environment determines the degree to which this potential is achieved. Yields are determined by the interaction of the crop's genetics with environmental factors, including the availability of elements essential for plant growth.

  Relatively few studies have looked at the total nutrient uptake of varieties of hybrids. The few studies that do exist reveal that there are differences among varieties in the ability to absorb, translocate, or metabolize various elements. In some varieties, elements are excluded by roots. In others, they may be absorbed but not translocated

to one or more plant parts. Changes in variety can require adjustments in soil fertility levels and even in interpretation of soil tests.

- Availability of nutrients.--The availability of nutrients is determined by factors that affect the ability of the soil to supply nutrients and by those that affect the plant's ability to use the nutrients. Nutrients obtained from the soil are derived through weathering of primary minerals, decomposition of organic matter, deposition from the atmosphere, application of fertilizer, seepage from other areas, and other sources. Once introduced into the soil, the nutrients are available to varying degrees.

  Until the past few decades, most farmers used manure and nitrogen-fixing legumes to maintain soil fertility. In the past two decades, however, they have shifted to chemical fertilizers as a source of plant nutrients. As the expected rapid increases in the cost of energy drive the cost of chemical fertilizers upward, efforts are needed to ensure that the correct amount of fertilizer is applied at the right time. Further, research should be directed towards improving use of manures and nitrogen fixing crops in supplying plant nutrients.

- Soil and water conservation.--Soil and water conservation measures can generally be grouped into three categories: (1) those that change land use from row crops to permanent vegetation in critically eroding areas, use crop rotations that contain more sod crops and small grain crops and fewer row crops, or use alternate strips of sod and row crops (strip-cropping); (2) those that use alternative cultural practices for crop production, such as conservation tillage, no-till double cropping, no-till sod planting, mulch tillage, and such solid-seeded row crops as soybeans, so that much of the soil surface is protected by residue most of the year; and (3) those that use practices and structures such as contouring, terracing, sod waterways, streambank stabilization, grade control structures, and sediment basins and ponds.

In most places, combinations of land use changes, cultural practice changes, and structures work best to keep soil erosion rates within allowable limits. Research should be undertaken to determine which combination of measures is most efficient and effective for a particular resource and use condition.

To accomplish this, it will be necessary to better define the interrelationships among cultural practices, climate, soils, and crops. For example, among the problems associated with the use of conservation tillage are reduced yields in some regions, lack of effective pest control, and reduced fertilizer efficiency. These problems must be resolved before many farmers will accept conservation tillage. The environmental impact of the various alternatives must be studied to ensure that the solution to an excessive erosion problem does not create other serious environmental problems. Finally, economic comparisons are needed among alternative solutions so that public funds can be used most efficiently and effectively.

<u>Expanding the Resource Base</u>.--There are a number of currently feasible alternatives available for expanding the size or capability of the resource base. First, there is an opportunity to convert nearly 135 million acres of

land that is currently in other uses but has medium to high potential for conversion to cropland. In all cases, the costs of conversion plus the values in the current use must be weighed against the potential need for and value of its use in agriculture. Unless program actions regulate the future use of this land, economic market forces will largely determine which land is converted and at what rate.

Second, the improvement of drainage on the 34.2 million acres of cropland that currently needs such improvement will be subject to similar market forces. The economics of improved onfarm drainage facilities are generally good, and it is likely that land users will readily invest in drainage facilities in response to relatively small increases in farm prices. The potential production that could be acquired through improved drainage would be equivalent to adding about 20.9 million acres to the cropland base.

Alternative Objective Levels

USDA's basic objective is to ensure adequate supplies of food and fiber for domestic needs. However, because the United States is an integral member of the world community and American agricultural exports are significant in world trade, USDA also wants to ensure that agricultural products are exported as long as this can be done without destroying our resources. Because of these two objectives, USDA established the following objective levels:

- Objective level 1.--To provide for the production of sufficient food and fiber to meet only the domestic needs of our population in the year 2030.
- Objective level 2.--To provide for domestic needs in the year 2030 plus a level of agricultural exports equal to the current level (1975-1977 average).
- Objective level 3.--To provide for domestic needs in the year 2030 plus a projected increase in agricultural exports.

Recommendations for Future Analysis

There is a continuing need to monitor the amount of soil and water conservation measures installed as well as their economic and environmental effects. Data on these effects can be combined with the inventorying and monitoring data that are being continually updated and improved for future RCA activities. There is also a need to gather information on the sociological and institutional factors that influence land users to decide whether or not to apply conservation measures on their lands. This information would help USDA better understand the attitudes of land users and managers concerning the need for conservation. Finally, there is a need to link practices, effects, and the sociological and institutional factors in order that more efficient programs of the proper size and scope can be developed to assure that the productive capability of our soil and water resources will be maintained.

References

Aro, Richard S. 1971. Evaluation of pinyon-juniper. Conversion to grassland. Journal of Range Management, 24: 3, pp. 185-197.

Branson, Farrel A., Gerald F. Gifford, and J. Robert Owen. 1972. Rangeland hydrology. Society for Range Management, Range Science Series No. 1.

Bredemieir, Lorenze. 1973. Brush inventory for nonfederal lands in the USA. U.S. Dep. Agric. Soil Conserv. Serv. Rep. (Unpub.)

Cable, D., and S. Clark Martin. 1975. Vegetation responses to grazing, rainfall, site condition, and mesquite control on semi-desert range. U.S. Dep. Agric., For. Serv. Resear. Pap. 149. Rocky Mountain Forest and Range Experiment Station.

McCorkle, J.S., and Arnold Heerwagen. 1951. Effects of range condition on livestock production. Journal of Farm Managers, 4: 4, pp. 242-248, table 2.

Osborn, James E., and Gerald V. Witkowski. 1974. Economic impact of brush encroachment in Texas. Southern Journal of Agricultural Economics, 6: 2.

Renau, D.R., and Robert Taylor. 1979. Economic analysis of erosion control options in Texas. In Best Management Practices for Agriculture and Silviculture, edited by C.S. Martin, F.W. Michael, R.C. Loehr, and D.A. Hdith, Ann Arbor Science.

United States Department of Commerce. 1977. Population estimates and projections. Series P-25, No. 704.

United States Department of Agriculture. 1978a. Agricultural statistics 1978. Government Printing Office, Washington, D.C.

United States Department of Agriculture. 1978b. 1977 National resource inventories.

United States Department of Agriculture, Science and Education Administration. 1979. Staff paper.

United States Department of Agriculture and the Environmental Protection Agency. 1979. The biologic and economic assessment of 2, 4, 5-T. A Report of the USDA-States-EPA, 245-7 RPAR Assessment Team. (Mimeo)

Section B-Potential Problem Area 2, Water Quality

Problem Statement

For the purposes of the Resources Conservation Act (RCA), water quality is defined as the presence or absence of pollution in the waters of the United States. Section 502 of the Clean Water Act Amendments of 1977 defines pollution as "the manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." It is clear from this definition that water quality is--

(1) a very broad and complex problem area.
(2) a function of man's value system, depending on the use that he makes of water.
(3) limited, as a problem area, to degradation of water as a result of man's activities, and does not include natural or background deterioration of water quality.

In the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), Congress established national water quality goals in order "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." These goals are:

(1) To eliminate the discharge of pollutants into navigable waters by 1985.
(2) To achieve a level of water quality by July 1, 1983, that protects and helps propagate fish, shellfish, and wildlife and provides for recreation in and on the water.
(3) To prohibit the discharge of pollutants in toxic amounts.

Pollutants covered in the analysis for RCA are (1) toxics, including pesticides and heavy metals (see glossary), (2) nutrients, primarily nitrogen and phosphorus, (3) organic wastes, (4) dissolved solids, and (5) sediment.

Pollution sources and their relative effects on water quality considered in this section are (1) point source pollution, (2) urban nonpoint source pollution, and (3) rural nonpoint source pollution (including individual disposal systems, agricultural and silvicultural nonpoint source pollution, and pollution from abandoned mines). See the glossary for definitions of "point source pollution" and "nonpoint source pollution."

Data Sources and Research.--Data on the kinds or sources of pollutants are not uniformly available. The Storage and Retrieval (STORET) water quality data bank maintained by the Environmental Protection Agency (EPA) contains the most current data on 4,000 indicators and pollutants. STORET will be expanded to cover 8,000 indicators and pollutants during fiscal year 1980. Public and private groups spend about $275 million annually to collect data on water quality.

Federal research and analyses are carried out primarily under the auspices of EPA and the Agricultural Research (AR) and Cooperative Research (CR) offices of the Science and Education Administration (SEA) in USDA. Economics, Statistics, and Cooperatives Service (ESCS) in USDA also contributes studies and analyses on water quality problems. EPA spends about $64 million and USDA about $30 million annually on water quality related research (House of Rep., 1979). Academic institutions, state agencies, local and regional

entities and private firms also conduct research on water quality. There is no precise information about the expenditures on research by these nonfederal groups.

The United States has also conducted significant research on water quality problems under international agreements, primarily with Canada and Mexico. The International Great Lakes Pollution from Land Use Activities Reference Group (PLUARG) has completed extensive studies of many important facets of water pollution. The Bureau of Reclamation, SEA-AR, and EPA are conducting research on dissolved solids in connection with the Colorado Salinity Control Act.

The Water Quality Problem.--Even if uniform nationwide data were available, no one statement could adequately describe water quality because it is judged by many standards for many purposes. Meeting nationwide water quality goals requires monitoring and controlling a host of pollutants that have different chemical, physical, and biological effects.

In a recent summary of state reports to Congress prepared according to requirements of Section 305(b) of the Clean Water Act, EPA indicated that water pollution affected 95 percent of the 246 hydrologic drainage basins in the United States in 1977 (EPA, 1978). This oversimplifies the situation, however, in that a basin identified as "affected" may not be affected in its entirety; pollution may be limited to one or two short segments. On the other hand, failure to report a problem does not necessarily mean that the basin is free of pollution; monitoring data may be lacking or state officials may be reluctant to identify a problem. This lack of data is particularly true where potential carcinogens or other toxic pollutants are present.

Different types of pollution degrade water quality in different ways. Efforts are now shifting toward control of toxic pollutants. Traditionally, however, control has focused on the most noticeable forms of pollution. These include bacterial contamination, which can make waters unsafe for recreation and for shellfish harvesting; oxygen depletion, which can kill fish; excessive discharges of nutrients, such as nitrogen and phosphorus, which can encourage nuisance growths of algae and other aquatic plants; and excessive levels of suspended solids, which can be unsightly, destroy aquatic habitats through sedimentation, and directly damage fish (figs. 3B-1 through 3B-3).

Bacteria, oxygen depletion, nutrients, and toxics are widespread problems caused by both point and nonpoint sources. Nationwide, point sources contribute to excess bacteria in 78 percent of the basins, to oxygen depletion in 79 percent, to excess nutrients in 69 percent, and to toxics in 44 percent. In the heavily populated Northeast and Great Lakes Regions, these percentages are even higher. There, point sources contribute to excess bacteria, oxygen depletion, excess nutrients, and toxics in 86, 89, 74, and 62 percent of the basins, respectively (EPA, 1978,). Bacteria and nutrient problems from point sources are generally the result of municipal discharges and combined sewer overflows, oxygen depletion is generally caused by municipal and industrial discharges, and toxics are usually contained in direct and indirect industrial discharges.

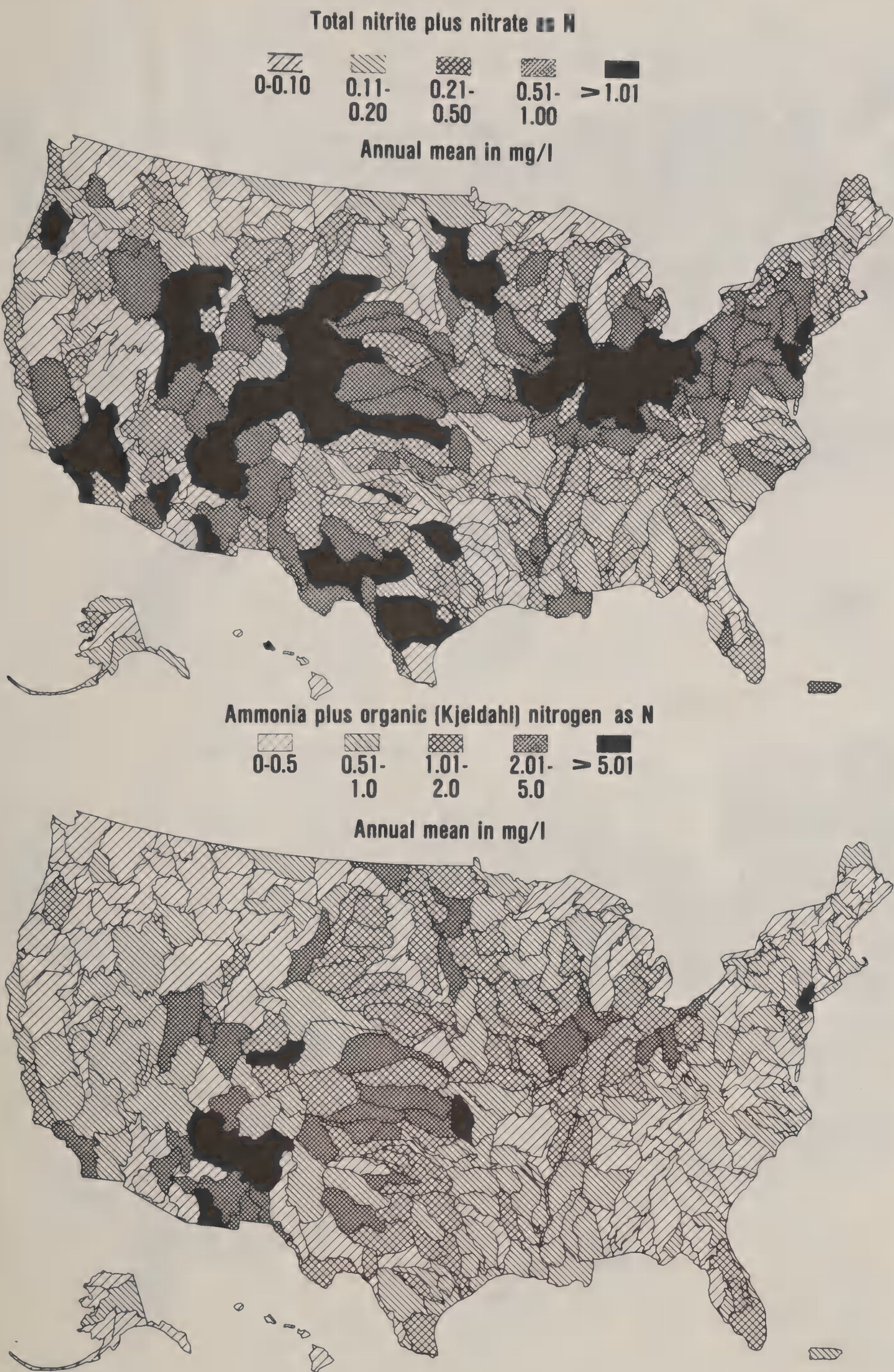


Figure 3B-1.--Mean concentrations of nitrogen at NASQAN stations during the 1977 water year. (CEQ, 1978)

Figure 3B-2.--Basins wholly or partly affected by bacteria problems in 1977. (Affected areas are shaded.) (EPA, 1978)

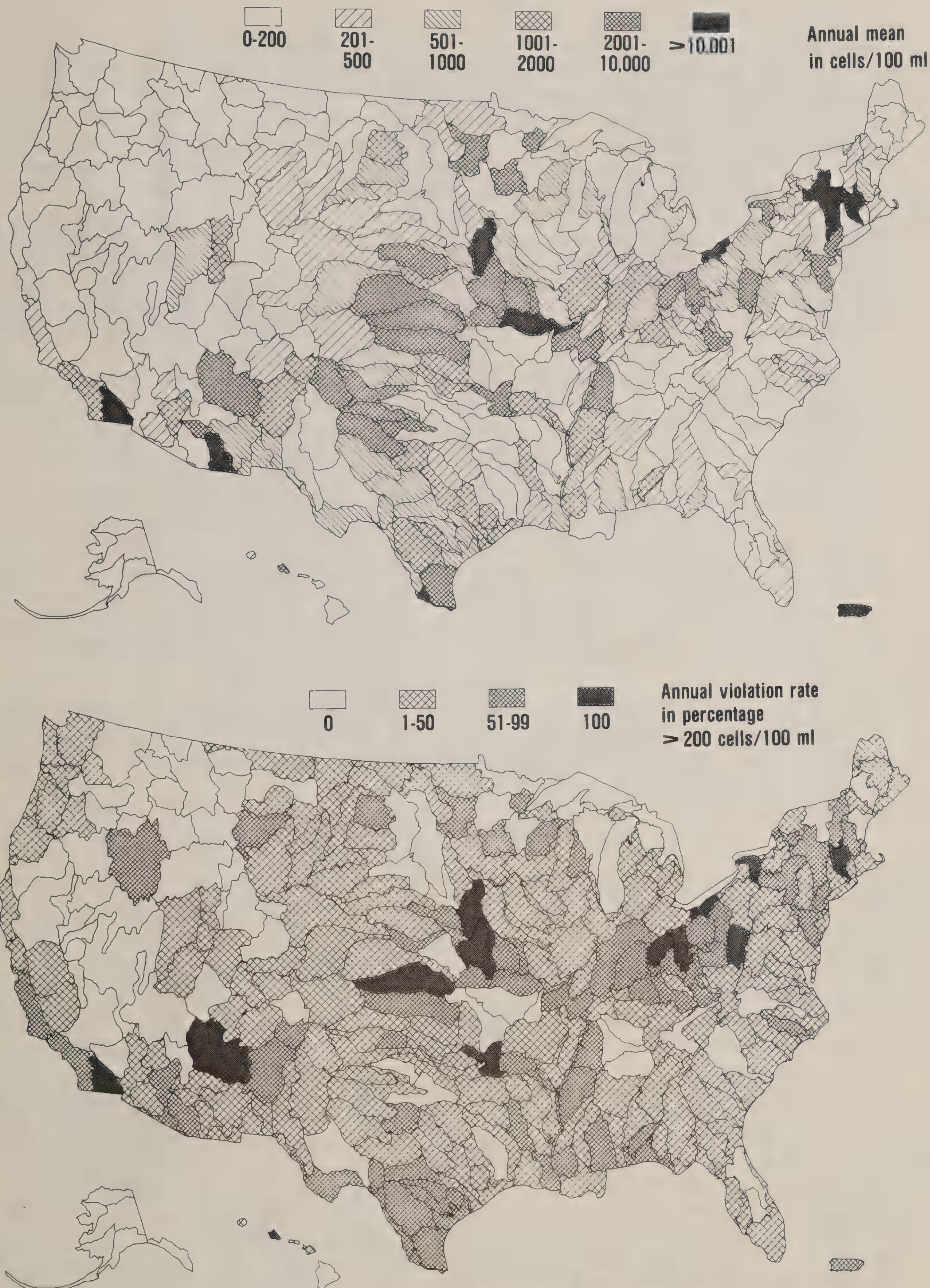


Figure 3B-3.--Levels of fecal coliform bacteria at NASQAN stations during the 1977 water year. (CEQ, 1978)

Across the country, nonpoint sources contribute to excess bacteria in 61 percent of the basins, to oxygen depletion in 51 percent, to excess nutrients in 56 percent, to pesticides in 22 percent, and to other toxics (metals from urban runoff and mining) in 32 percent of the basins. The primary nonpoint sources that cause these and other problems are agricultural runoff, which affects 68 percent of the basins; urban runoff, which affects 52 percent; and individual disposal systems, which affect 43 percent (EPA, 1978).

High nutrient concentrations occur in the Midwest where fertilizer and livestock wastes are principal sources of nitrogen and phosphorus in water. Nutrient levels are also high in the waters of urban industrialized regions, such as the Northeast and the Great Lakes Regions, where municipal sewage, urban runoff, and industrial wastes commonly contain nitrogen and phosphorus.

Improperly treated sewage, sewer overflows, poorly operated septic systems, ships and boats, and livestock are major sources of bacterial pollution. Water bodies with excessive levels of fecal bacteria cannot be used for swimming, boating, or fishing because of the threat of waterborne disease.

As figures 3B-2 and 3B-3 show, the worst bacterial pollution problems are in areas of high human or livestock population, such as the Northeast and the Ohio, lower Missouri, and Mississippi River Basins. Problems are least severe in the Great Plains, the High Plains, the Northwest, and the Atlantic Coastal Plain, where population densities are generally low. Figure 3B-4 shows the location of fishkill reports for the period 1960-76. It indicates the effects of various pollutants, including oxygen depletion, toxics, and suspended solids.

Public opinion surveys continually indicate concern about water pollution and a willingness to pay for its control in spite of increasing inflation and frustrations over federal regulations. See Part I of the RCA Appraisal, Chapter 13, page 13-23.

Point Sources of Pollution

There are about 75,000 point sources of water pollution in the United States, primarily municipal waste water treatment plants and industrial facilities that use streams and lakes to dispose of wastes. These point sources restricted the intended uses of water in 91 percent of the basins across the Nation in 1977. Common pollution problems were oxygen depletion or presence of excessive amounts of suspended solids, bacteria, oil and grease, heavy metals, and toxic chemicals. Point sources also cause thermal pollution (see glossary), pH problems, and excessive levels of nutrients (fig. 3B-5).

Industrial discharges.--Industrial discharges cause oxygen depletion and contribute to excessive levels of suspended solids, oil and grease, heavy metals, and toxic chemicals. Some types of industrial effluent also cause thermal pollution and pH problems. For example, discharges of water used for cooling in electric power plants can elevate receiving water temperatures to levels that significantly affect aquatic life. Oxygen-demanding wastes are present in runoff from sawmills; pulp, paper, and fiberboard manufacturing plants; fruit and vegetable canning factories; meat slaughtering and processing plants; and similar sources. Table 3B-1 shows estimated pollution loadings from selected agricultural processing industries.

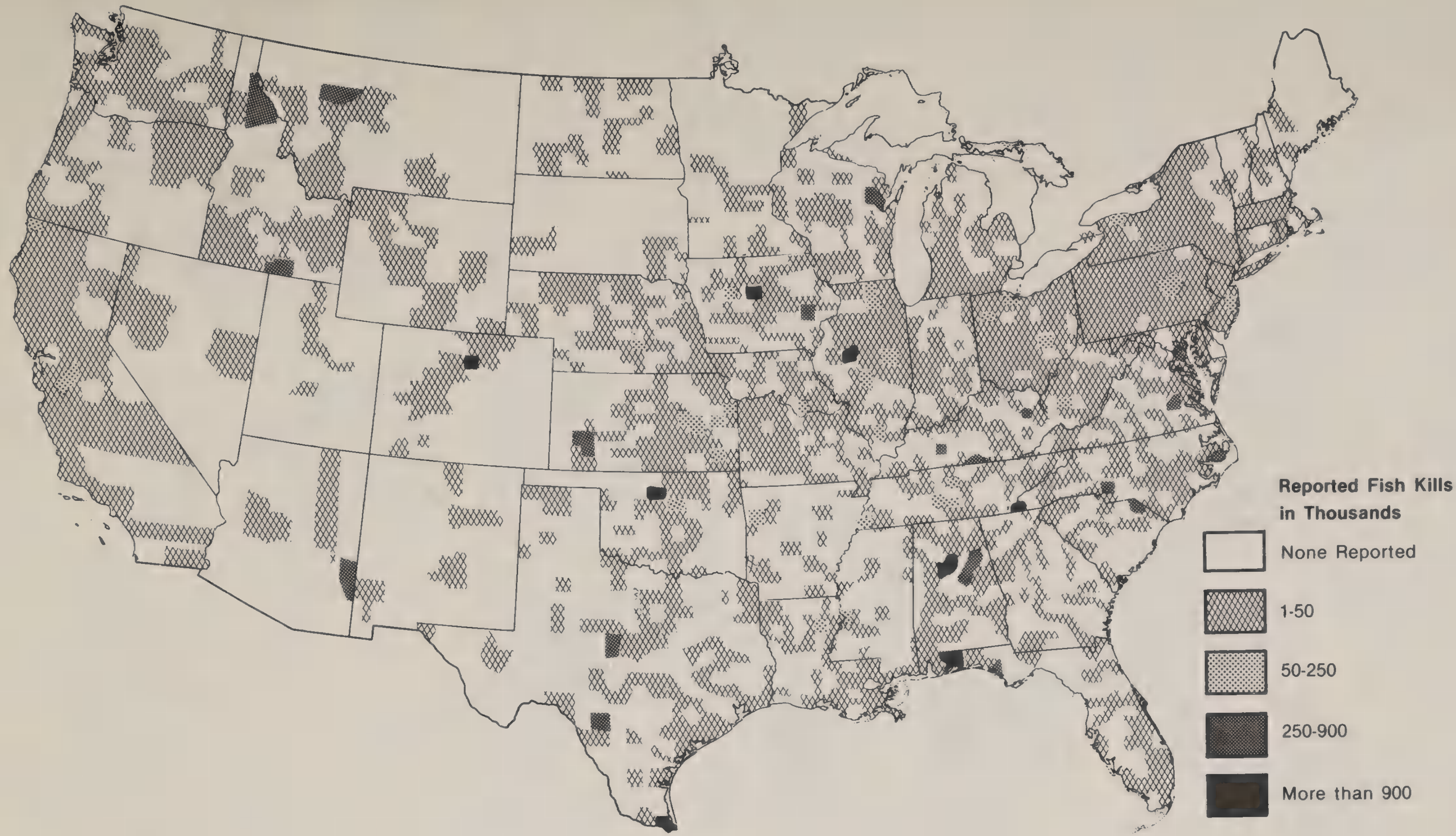


Figure 3B-4.--Fishkills from 1960-1976, within counties. Source: EPA STORET system, 1976.

Figure 3B-5.--Basins wholly or partly affected by nutrients from point sources in 1977. (Affected basins are shaded.) (CEQ, 1978)

Table 3B-1.--Estimated pollution loadings of selected agricultural processing industries 1/

Processing industry	Annual production	5-day BOD: Data in literature [2]	5-day BOD: Lb. BOD per 1,000 lb. processed	5-day BOD: Potential daily load	Potential daily population equivalent
(1)	(2)	(3)	(4)	(5)	(6)
	Million pounds			*1,000 pounds*	*Millions*
CANNERIES:					
Apples	1,218	32 gal. 3,600 p.p.m. BOD per case (24 No. 2½ cans).	13.3	44	0.26
Peaches	2,970	50 gal. 2,000 p.p.m. BOD per case (as above).	20.8	169	1.02
Corn	2,364	19.5 lb. BOD per ton corn processed	9.8	63	.38
Tomatoes	9,790	8.4 lb. BOD per ton tomatoes processed	4.2	113	.68
Canning (total)				1,370	8
CORN WET MILLING	10,800	1 bu.=1–2 PE	4.5	133	.80
COTTON (processed through basic dyeing step).	4,600	PE: Sizing 2; Desizing 96; Kiering 108; Bleaching 17; Scouring 12; Mercerizing 83; Basic dyeing 90 (per 1,000 lb. goods).	68	857	5.14
DAIRY:					
Fluid mild	59,000	10 [3]	[4] 1.0	162	1.0
Evaporated milk	1,888	10.5 [3]	[4] 2.25	11.6	.07
NFDM	2,176	25.0 [3]	[4] 26.4	157	.945
Cheddar cheese	1,157	24.5 [3]	[4] 24.5	77.6	.465
Cheddar whey (dried)	20 percent of total.	17.0 [3]		9.7	.06
Cheddar whey	50 percent of total.	350 [3]		500	3.0
Cottage cheese	1,424	350 [3]	[4] 26.5	64.5	.38
Cottage cheese whey	7,500	350 [3]	[4] 165	1,000	6.0
HIDES AND LEATHER	1,300	650 gal. 1,500 p.p.m. per 100 lb. hides	81	300	.18
MEAT:					
Slaughtering and packing.	59,400	14 lb. BOD per 1,000 lb. live weight	14.0	2,300	13.7
PAPER AND PULP:					
Wood pulp	66,000	300 lb. BOD per ton of pulp	150.0	27,000	162.0
Paper and paperboard	96,600	68 lb. BOD per ton of paper	34.0	9,000	54
POTATOES:					
Chips	7.1	29.3 lb. BOD per ton raw potatoes	14.6	106	.64
Dehydrated	2.7	71.1 lb. BOD per ton raw potatoes	35.6	93	.58
Flour and starch	3.2	57 lb. BOD per ton raw potatoes	28.5	91	.55
Frozen french fries	5.4	22 lb. BOD per ton raw potatoes	11.0	57	.34
POULTRY	8,200	33 lb. BOD per 1,000 birds	10.0	225	1.3
SOAP AND FATTY ACIDS	770	1.75 lb. BOD per lb. soap made	1,750.0	3,700	
SOYBEAN	27,200	1.7 lb. BOD per 100 bu	.19	14	.085
SUGAR REFINING:					
Cane	48,000	5.31 lb. BOD per ton	Av. 3.0	800	4.8
Beet	47,000	6.64 lb. BOD per ton			
WOOL SCOURING	130	8 gal. 4,000 p.p.m	267	100	.6

[1] Hoover, S. R., and Jasewitz, Leonore B. Agricultural Processing Wastes. Presented at Amer. Assoc. Adv. Sci. Symposium, Washington, D.C., Dec. 27, 1966.

[2] PE=Population equivalent.
[3] Pounds BOD/10,000 lb. milk equivalent.
[4] Milk equivalent.

As would be expected, the Northeast and Great Lakes Regions have the greatest problems with industrial discharges (fig. 3B-6). Industrial discharges affected 88 percent of the basins in these two regions, as compared to 65 percent in the rest of the country, and only 23 percent in the Southwest Region (table 3B-2).

Table 3B-2.--Percentage of basins wholly or partly affected by point source pollution, by type of source

Region (Number of basins)	Industrial	Municipal	Combined sewer overflows
Northeast (40)----------------	95	95	60
Southeast (47)----------------	74	91	17
Great Lakes (41)--------------	80	95	37
North Central (35)------------	74	86	6
South Central (30)------------	70	100	0
Southwest (22)----------------	23	64	0
Northwest (22)----------------	55	73	14
Islands (9)-------------------	89	100	0
Total (246)--------------	72	89	21

The type of water pollution from industrial point sources also varies by region. In the Northeast, Great Lakes, and North Central Regions, heavy metals, toxic chemicals, and other industrial chemicals from heavy industries are much more extensive than in the Southeast and Northwest Regions, where much of the industry is food and timber processing. The wastes from these industries are more organic and more likely to cause problems with oxygen demand and excessive nutrients, although the pulp and paper industries also discharge some toxic materials.

In the Northeast, Great Lakes, and North Central Regions, heavy metals from point sources affect 55 percent of the basins and nonmetal toxics affect 42 percent (table 3B-3). In the rest of the country, heavy metals from point sources affect only 23 percent of the basins and nonmetal toxics affect only 15 percent. The relative magnitude of toxics problems in the "heavy industry" regions, however, is much greater than the percentage of affected basins would indicate.

A classic illustration of the effects of heavy industry on water quality is the severe degradation of the Mahoning River as it passes through Warren and Youngstown, Ohio, both major steel centers. In this stretch of the river, there are large increases in lead, zinc, and phenols, all toxic pollutants that can severely harm aquatic life. Improvement is expected as plants along the river begin treating waste water.

Municipal discharges.--Municipal discharges generally include inadequately treated sewage. Where discharge from a municipal plant is causing a problem because an industrial discharge into that plant has not received adequate pretreatment, states usually report it as an industrial discharge problem.

Figure 3B-6.--Basins wholly or partly affected by industrial discharges in 1977. (Affected basins are shaded.) (EPA, 1978)

Table 3B-3.--Percentage of basins wholly or partly affected by point source pollution, by type of pollutant

Region (Number of basins)	Thermal	Bacteria	Oxygen depletion	Nutrients	Suspended solids	Dissolved solids	pH	Oil and grease	Heavy metal	Nonmetal toxics
Northeast (40)-------	33	93	93	78	70	13	15	35	58	43
Southeast (47)-------	11	77	89	70	26	9	17	6	26	28
Great Lakes (41)-----	24	80	85	71	44	27	24	34	51	59
North Central (35)---	11	89	80	74	23	20	14	0	57	23
South Central (30)---	3	73	87	83	30	30	10	13	43	7
Southwest (22)-------	5	50	38	41	14	23	5	5	9	5
Northwest (22)-------	0	68	55	55	23	5	5	0	5	14
Islands--------------	33	89	78	56	33	11	0	44	22	11
Total (246)-----	15	78	79	69	35	17	14	16	38	28

The pollutants in municipal discharges that most often cause problems are fecal coliform bacteria, oxygen-demanding loads, and nutrients such as phosphorus and nitrogen. These pollutants cause the most widely reported water quality problems from point sources (table 3B-3). The states attributed the degraded water quality in many basins that is caused by excess bacteria, nutrients, oxygen-demanding loads, and suspended solids to a combination of different types of point source discharges.

Municipal discharges affect water quality in 89 percent of the basins across the country (table 3B-2). As would be expected, the more heavily populated regions generally have a higher percentage of affected basins. Even in the sparsely populated Southwest Region, 64 percent of the basins have some problems from municipal discharges (fig. 3B-7). Most of these problems are caused by inadequate treatment or overloaded plants, and the states expected that most will be resolved as grants for construction become available and treatment facilities are upgraded.

Combined sewer overflows.--Combined sewer overflows occur when excessive runoff from rain joins normal sewage flows in systems where storm and sanitary sewers are combined. The resulting overflow discharges pollutants from both the sewage (mostly bacteria, nutrients, and oxygen-demanding loads) and the urban runoff (mostly suspended solids, heavy metals, and oil and grease). These discharges can severely degrade water quality. Combined sewers are generally located in older cities and, therefore, problems from combined sewer overflows occur primarily in the Northeast and Great Lakes Regions (fig. 3B-8). Almost half of the basins in those regions have problems from combined sewers, as compared to only 8 percent of the basins in the rest of the country (table 3B-2). Some states in the Northeast and Great Lakes Regions report that combined sewer overflows cause the most serious water quality problems in some basins.

Trends.--Many of the pollution control facilities built during the past decade are just beginning to operate. Evaluating their effectiveness requires uniform data on plant performance and water quality. Fortunately, improved data networks are now providing the means for judging changes in water quality.

Uniform water quality data from a national network of stations cover a period of only a few years, so it is premature to characterize trends definitively. However, bacteria levels have improved through the third year. Figure 3B-9 shows levels of fecal coliform bacteria from measurements at National Stream Quality Accounting Network (NASQAN) stations during the 1975-77 "water years" (see glossary). The "violation rates" shown in the figure are the percentage of measurements in which concentrations of fecal coliform bacteria exceeded the recommended maximum for safe swimming, which many states and the Council on Environmental Quality (CEQ) define as more than 200 cells per 100 milliliters of water. (There is no legal uniform national standard; local standards vary with water use and local laws and sometimes differ from nationally recommended criteria.) Improvement is apparent in several populous regions, particularly in the industrial urban belt south of the Great Lakes.

No similar patterns of improvement are yet apparent for other pollutants, although levels of suspended material, nutrients, oil and grease, oxygen-

Figure 3B-7.--Basins wholly or partly affected by municipal discharges in 1977. (Affected basins are shaded.) (CEQ, 1978)

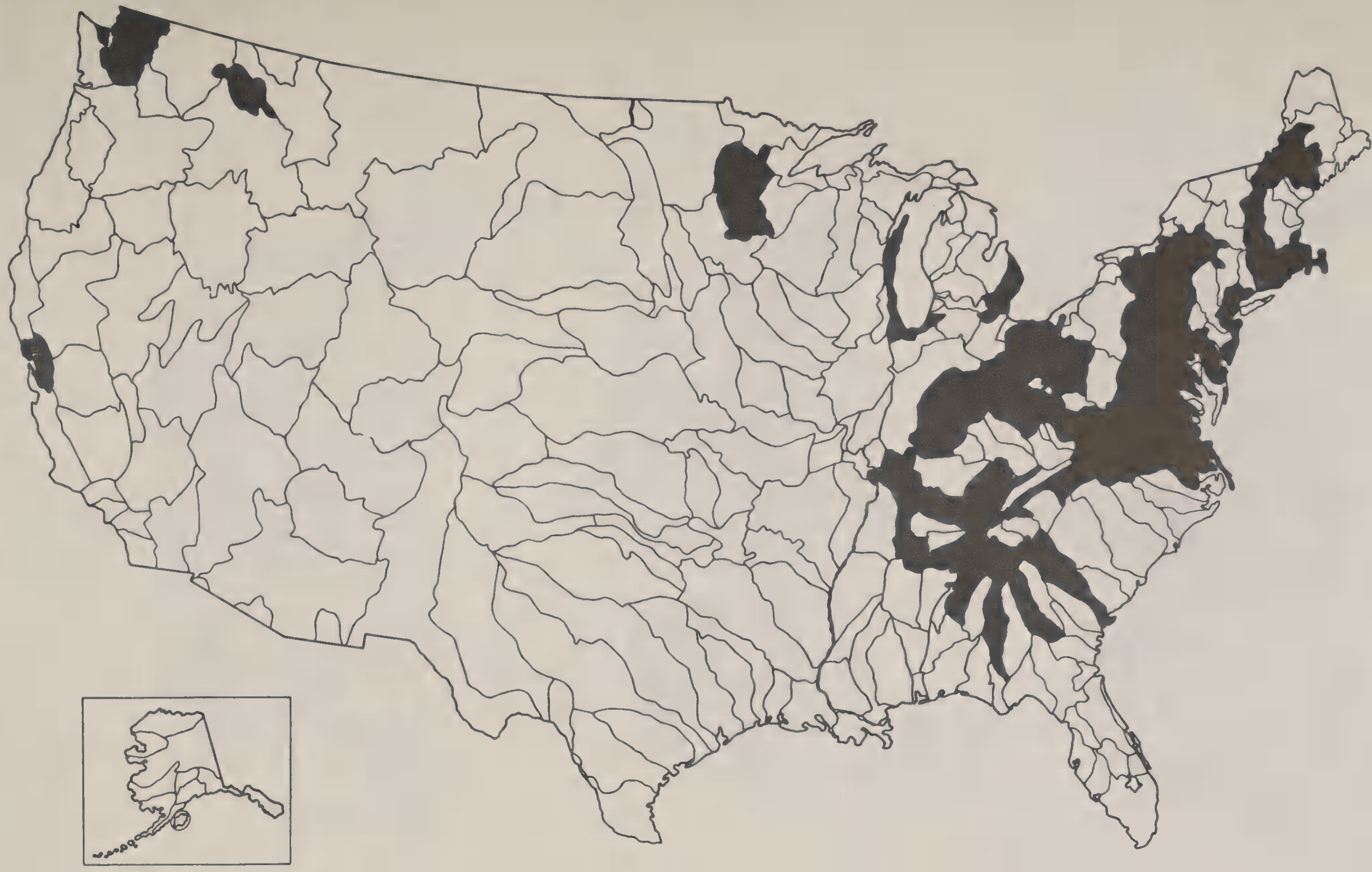


Figure 3B-8.--Basins wholly or partly affected by combined sewer overflows in 1977. (Affected areas are shaded.) (EPA, 1978)

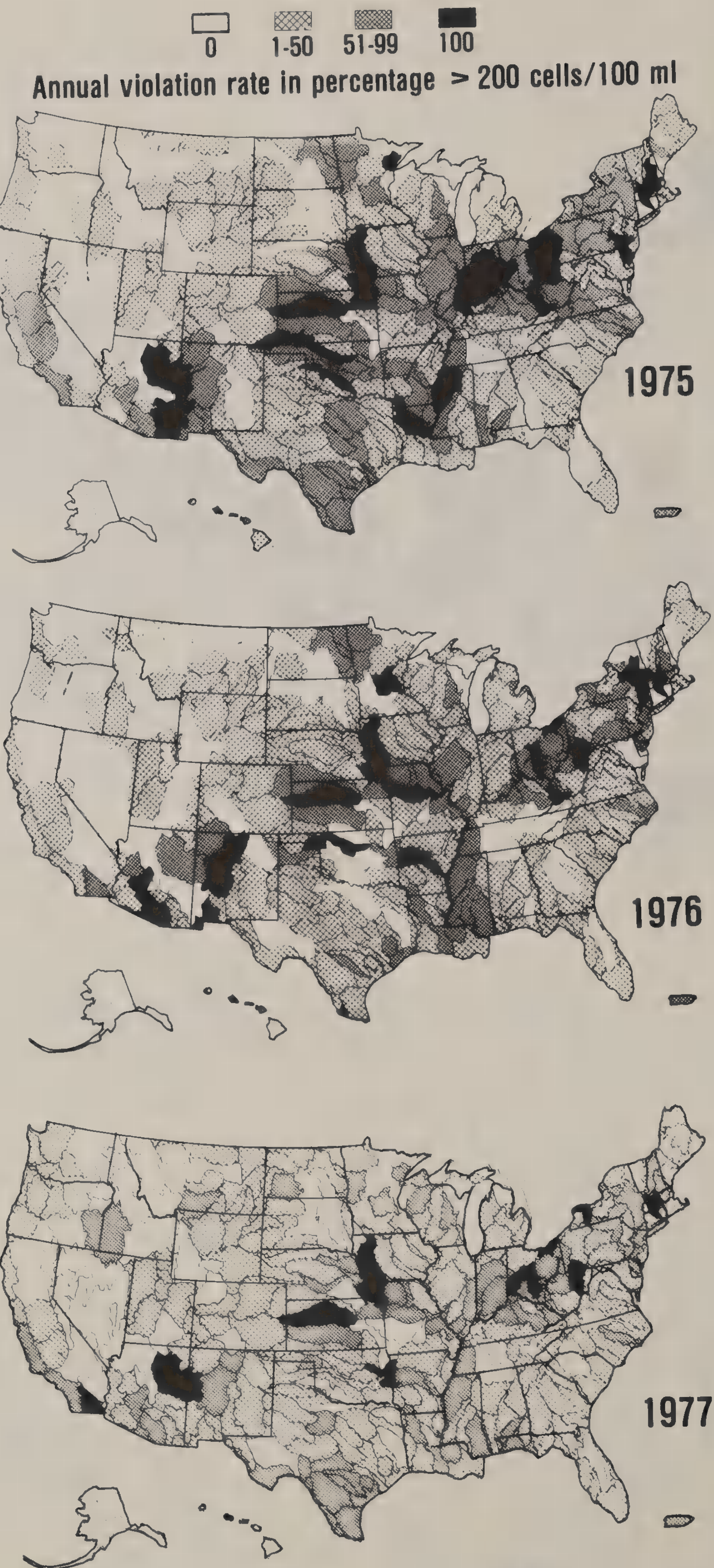


Figure 3B-9.--Fecal coliform bacteria at NASQAN stations during the 1975-77 water years. (CEQ, 1978)

demanding substances, and other materials should decline as pollution control becomes more effective. It should be noted, however, that nonpoint sources contribute heavily to excessive levels of some of these substances.

Table 3B-4 summarizes 3 years' data on stream accounting units (see glossary) where there were statistically significant patterns in water quality measurements. These accounting units were tested at the 90 percent level for seven pollutants (CEQ, 1978). The data indicate that the water quality, as measured in terms of levels of fecal coliform bacteria, has improved at 7.3 percent of the NASQAN stations and, as measured in terms of levels of oxygen, it has improved at 4.5 percent of the stations. More stations showed improvement than deterioration in these two areas. More stations showed deterioration than improvement in measurements of nitrogen, phosphorus, fecal streptococci bacteria, and dissolved solids. For all characteristics measured, most stations (74 to 93 percent) showed no statistically significant change.

Table 3B-4.--Water quality changes at NASQAN stations, 1975-77

Water quality characteristic	Percentage of stations reporting--		
	Improvement	No change	Deterioration
Fecal coliform bacteria-----	7.3	88.9	3.8
Inorganic nitrogen----------	5.8	86.7	7.5
Organic nitrogen------------	3.8	83.4	12.8
Total phosphorus------------	4.3	83.2	12.5
Dissolved oxygen------------	4.5	92.9	2.6
Fecal streptococci bacteria-	1.8	87.3	10.9
Dissolved solids------------	4.1	74.1	21.8

Urban Nonpoint Source Pollution

Pollution in stormwater runoff is a growing problem that is aggravated by increasing urbanization. Urbanization changes the hydrologic cycle by expanding the areas impervious to rainfall. This expansion increases the amount and rate of runoff. As runoff flows through urban areas, it flushes dust, automobile emissions, litter, and sediment into receiving waters.

Urban runoff is a primary cause of degraded water quality in heavily populated areas. It contains almost every type of pollutant. The most damaging are suspended solids and toxics, particularly heavy metals, but urban runoff also contains bacteria, oxygen-demanding loads, nutrients, oil and grease, and other pollutants. Following are specific examples of problems caused by urban runoff (EPA, 1979b).

- Suspended solids.--Decreasing point source pollution under the current federal program will only slightly improve the water quality of the lower Charles River (Boston, Massachusetts) because it will not eliminate stormwater sewers and combined sewers from overflowing at 50 points along the bank. Instream treatment primarily reduces loadings of phos-

phorus and suspended solids and levels of algae and bacteria from upstream. Control of combined sewers and reduction in urban runoff loadings are necessary to guarantee water of swimmable quality.

- Nutrients.--A study of Lake Washington (Seattle, Washington) found heavy nutrient loadings, mainly from urban stormwater runoff.

- Oxygen depletion.--In the Potomac River, sewer overflows and urban stormwater runoff reduce dissolved oxygen by about 2 milligrams per liter (mg/l) for a 5-day period after storms. One rainfall out of four causes overflows (assuming point source control). About once a week during lower quartile summer flow (see glossary), dissolved oxygen will be less than 5 mg/l and about once a month will approach 3 mg/l.

- Toxics.--A recent study shows that in Milwaukee, Wisconsin, 12 pounds of polychlorinated biphenyls, 5,400 pounds of lead, 7,600 pounds of zinc, 2,100 pounds of copper, and 170 pounds of chromium were available for wash-off resulting from a storm.

Fifty-two percent of the Nation's basins are affected by urban runoff. As would be expected, the highest percentage of affected basins (70 percent) is in the densely populated Northeast Region, and the lowest percentage (23 percent) is in the Southwest and Northwest Regions (EPA, 1977). Following are specific examples of sources of pollution in urban runoff (EPA, 1979b).

- Meteorological.--About 37 tons of dust fell per square mile per month in Chicago in 1966.

- Traffic.--A study of the Washington, D.C., area found that on a comparable scale, suspended solids entering water from traffic were 104 times greater than those from secondary treated effluent. The loading rates of lead from traffic were 1,015 times greater than those from secondary treated effluent. These figures are based on runoff from a 2-hour storm.

- Litter.--According to a study conducted in Washington, D.C., litter accounted for about 20 percent of the pollutants entering water from streets.

- Construction.--In Gaithersburg, Maryland, construction caused gross erosion of 188 tons per acre per year, of which 73 tons entered streams and water bodies.

Trends.--The magnitude of pollution from urban runoff is shown in figures 3B-10 through 3B-13. Figure 3B-10 compares point source contributions with urban runoff over time. Although control of point sources reduced the loading of industrial and municipal discharges, urban runoff still increases in severity as a result of the growth of urban areas. If left uncontrolled, urban runoff will eventually be the major source of water pollution. Figures 3B-11 and 3B-12 compare pollution from urban runoff with pollution from combined sewer overflows and treatment facilities on an average daily basis in 1973 and as projected for 1990. Figure 3B-13 compares pollution from urban runoff to pollution from treatment facilities on the basis of the loadings that occur during a single storm (for rainfall of 0.1 inch/hour with

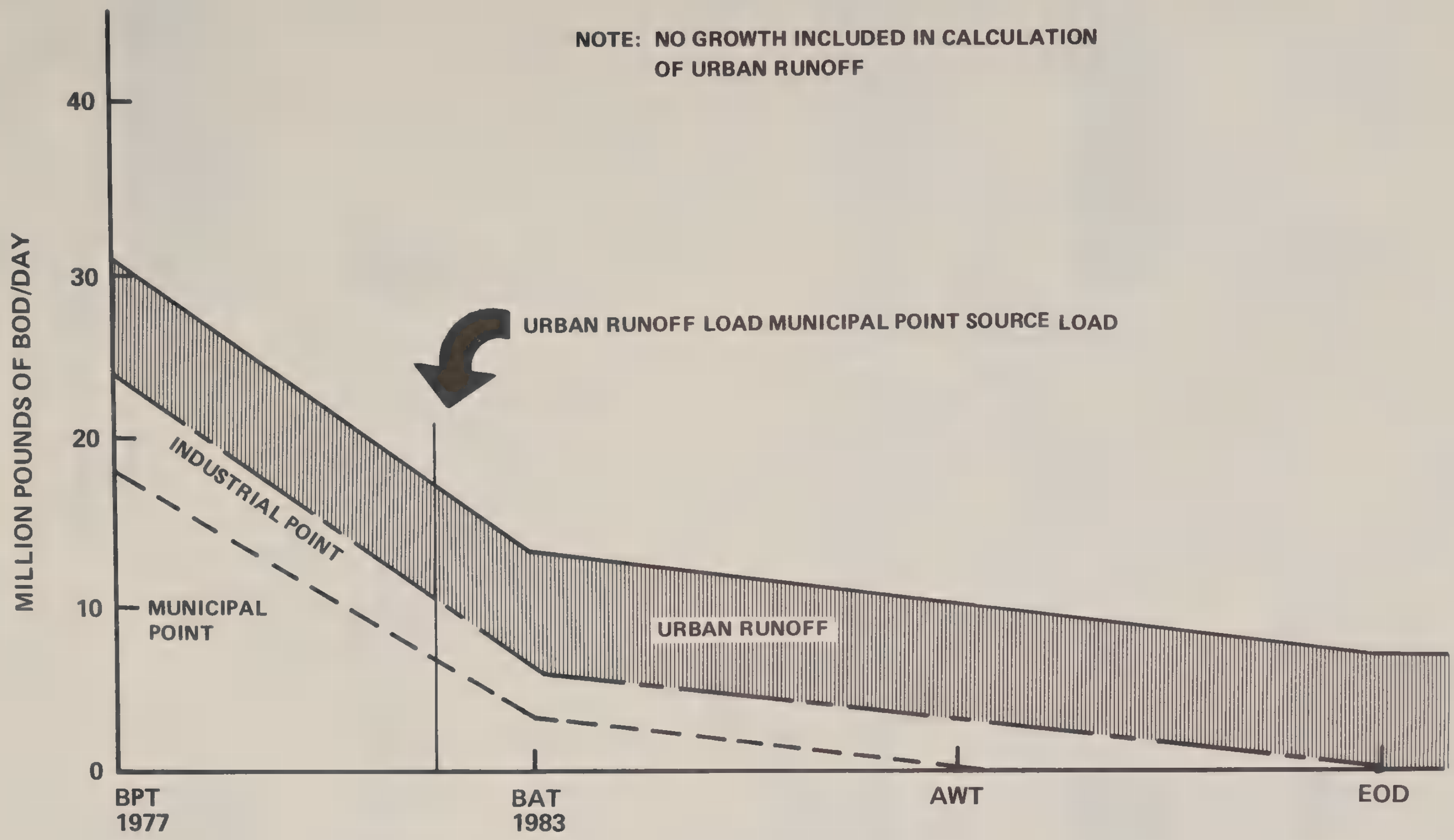


Figure 3B-10.--Pollution from urban runoff compared to that from point sources. Source: National Commission on Water Quality Staff Report, January 1976.

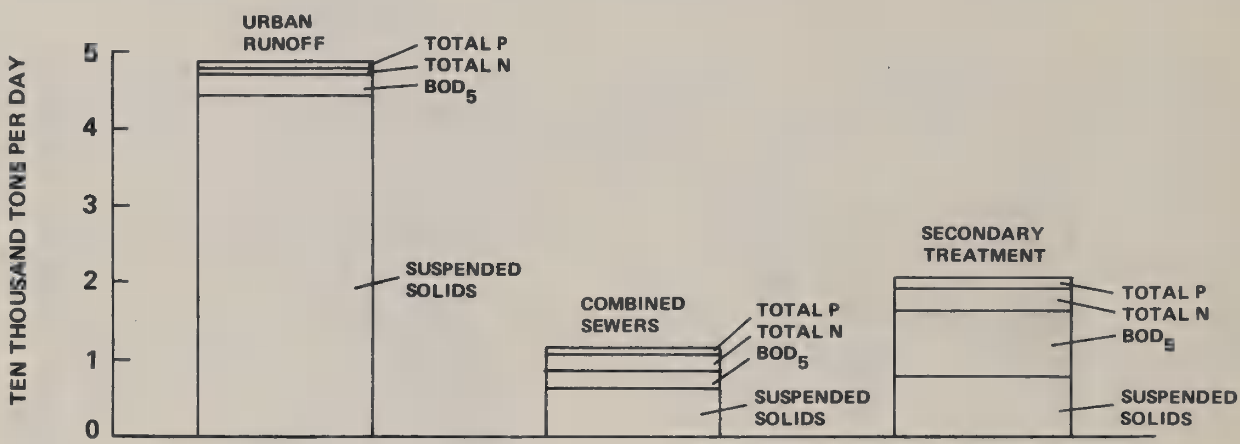


Figure 3B-11.--A comparison of urban runoff, combined sewers, and secondary treatment in 1973. (Estimated total daily pollutant loadings for the urbanized United States.) Source: National Commission on Water Quality Staff Report, January 1976.

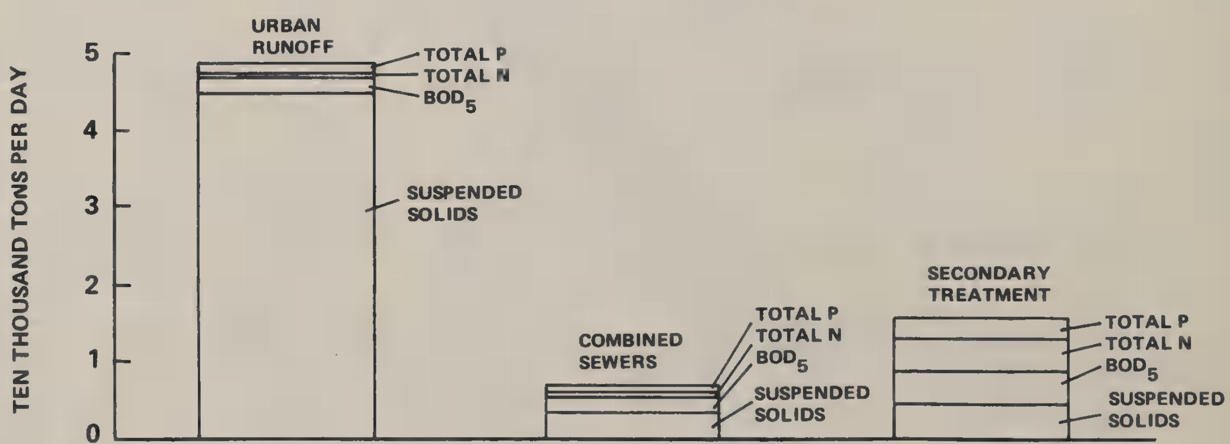


Figure 3B-12.--A comparison of urban runoff, combined sewers, and secondary treatment in 1990. (Estimated total daily pollutant loadings for the urbanized United States.) Source: National Commission on Water Quality Staff Report, January 1976.

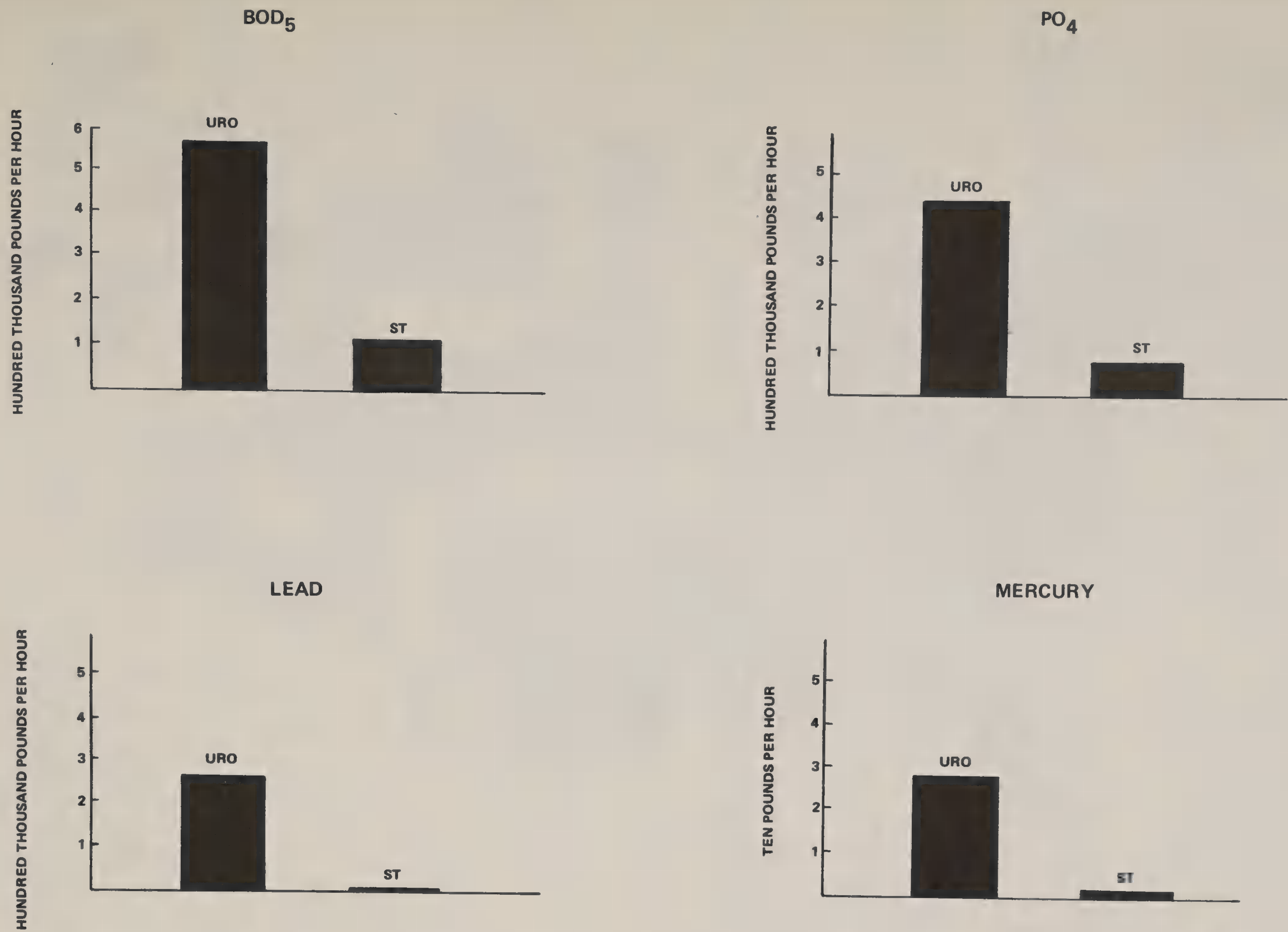


Figure 3B-13.--Representative pollutant loadings during a storm. Source: Environmental Protection Agency. 1972. Water pollution aspects of street surface contaminants. (EPA Publ. R2-72-081)

a peak intensity of 0.5 inch/hour). Both comparisons show that urban runoff is a major problem. However, in some situations suspended solids may not be as serious a concern as other pollutants. Case histories underline the extent and effect of urban runoff. All of this evidence shows that controlling point sources alone will not achieve national water quality goals.

Rural Nonpoint Source Pollution

Nonpoint source pollution in rural areas comes primarily from individual disposal systems and from agricultural lands. Runoff carries such nonpoint source pollutants as sediment, acid mine debris, and pesticides into streams. Nonpoint source pollutants now account for more than half the pollutants entering the Nation's waterways (GAO, 1977).

Individual Disposal Systems.--Table 3B-5 shows that more than 16 million households, or about one-fourth of all dwellings, were served by private sewage systems in 1970. This number is increasing by about 500,000 units per year. Therefore, any control of rural nonpoint source pollution must consider the increasing number of private sewage systems. Failures in these systems pose a significant problem in meeting national water quality goals. States reported water pollution from individual disposal systems in 43 percent of the Nation's basins (fig. 3B-14). In most cases, the problems result from inadequate or malfunctioning systems that contaminate surface or ground water.

Table 3B-5.--Dwellings and population served by sewers and on-lot sewage disposal systems in the United States, 1970

Sewage disposal	Dwellings served	Population served 1/
Public sewer----------------	48,187,675	144,625,187
Septic tank or cesspool------	16,601,792	49,826,792
Other-----------------------	2,904,375	8,716,872
Total------------------	67,693,842	203,168,851

1/ Assuming three occupants per dwelling.
Source: 1970 Census of Housing.

The major pollutants from individual disposal systems are bacteria and, to a lesser extent, nutrients. In the Islands and the Northeast Regions, where these problems were most widely reported, bacteria from nonpoint sources affected 73 percent of the basins, compared to 58 percent in the rest of the country (EPA, 1978). However, since bacteria also come from several other major nonpoint sources, it is difficult to evaluate the specific impact of individual disposal systems. In addition, 50 of the 176 areawide planning agencies view failing septic systems as a major concern and 7 states consider failing septic systems a problem.

Figure 3B-15 shows the geographical distribution of septic systems. States where more than 35 percent of the households use these systems are in New

Figure 3B-14.--Basins wholly or partly affected by pollution from individual disposal systems. (Affected basins are shaded.) (EPA, 1978)

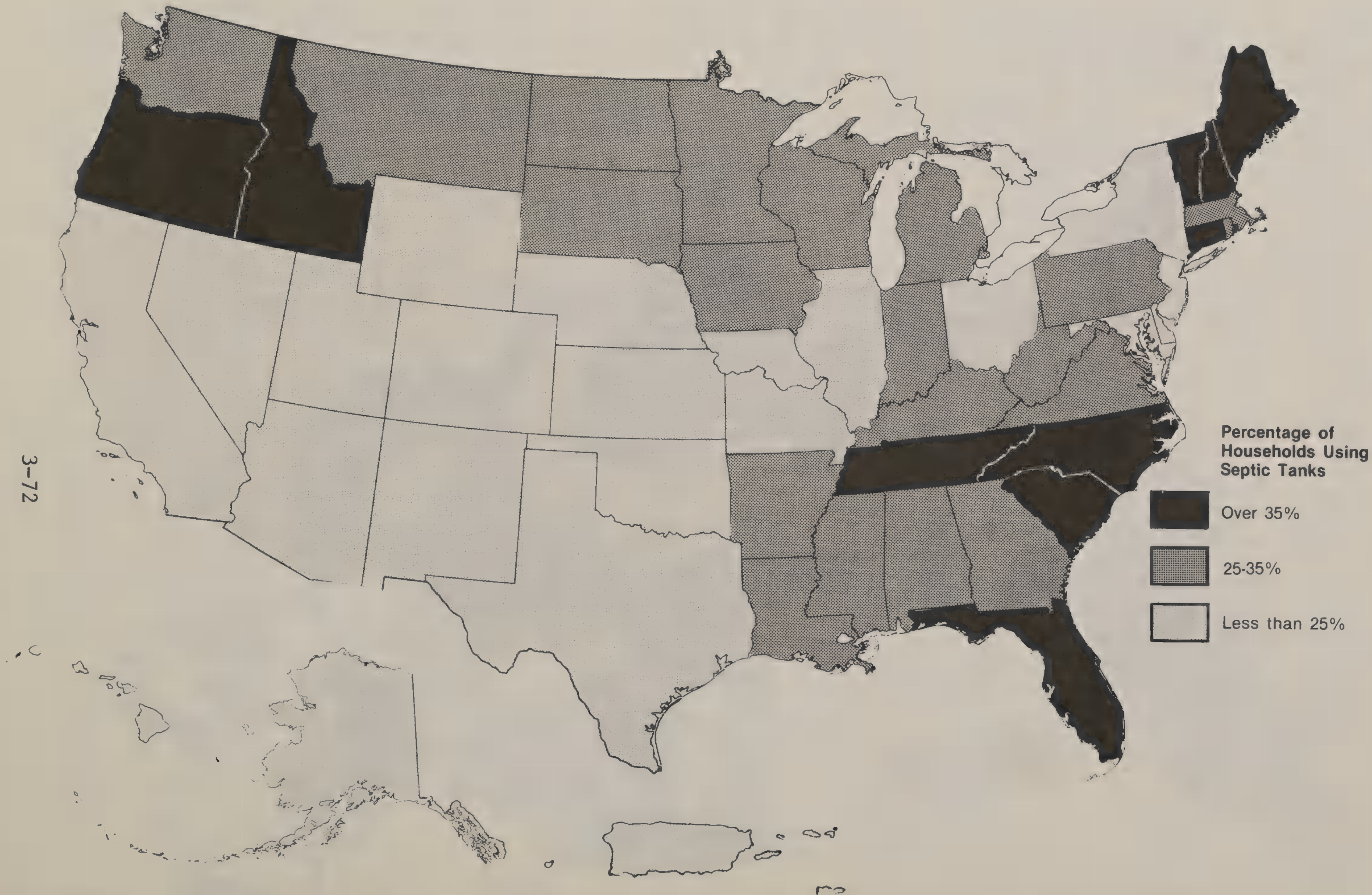


Figure 3B-15.--Distribution of onsite septic systems, by state. Source: Willem A. van Eck, et al. 1978. Report No. AP-770. Land and Water Information Series No. 1. Onsite Waste Water Disposal, 1978 Conference Proceedings.

England, the Southeast, and the Pacific Northwest. Most states in the North Central, Northeast, and Southeast Regions report only slightly lower use of these onsite disposal facilities. Only 10 to 20 percent of the households in Southwest Region use septic tanks.

In many counties in New Jersey, New York, California, and other states, more than 50,000 households use onsite waste disposal systems, but statewide use appears to be less significant. Areas where more than 100,000 households use onsite waste disposal systems include the suburbs of New York, Los Angeles, and Miami. Figure 3B-16 shows the density of onsite waste disposal systems, by county. Table 3B-6 lists the amount of septage generated, by state. Future programs for an area must include provisions for adequate disposal of septage.

The Environmental Protection Agency, the U.S. Department of Housing and Urban Development, and the U.S. Department of Agriculture all have programs to assist small communities with their waste treatment facilities. Many of these programs promote innovation in private sewage facilities. If they are properly designed and maintained, many innovative facilities are viable alternatives to more costly conventional systems.

In 1977, amendments to the Federal Pollution Control Act (Public Law 95-217) recognized the need for more flexible requirements for waste treatment facilities. These amendments allow people in rural areas and small communities to consider alternatives, such as upgrading existing onsite facilities, using small waste treatment systems, and establishing small regional treatment districts to centrally manage all types of systems. The Act now requires that at least 4 percent of the funds for construction grants be set aside for rural states. Cost sharing of 85 percent is allowed for septic tanks, with soil absorption fields; various add-ons; alternatives to septic tanks, such as mound systems, aerobic units, and low-water or no-water toilets with greywater treatment systems; and pressure, vacuum, and small diameter gravity sewers.

Federal grants provide $80 million annually to control problems in individual disposal systems. USDA provides both technical and financial assistance to landowners. The Soil Conservation Service (SCS) gives technical guidance on the suitability of soils for septic systems. The 1979 Farmers Home Administration (FmHA) budget for single family housing is $2.867 billion, about 5 percent of which is spent on individual disposal systems. Present FmHA policy emphasizes the use of central sewer and water systems to minimize water quality problems. State or local governments are responsible for certifying the adequacy of individual disposal systems.

<u>Agricultural Nonpoint Sources</u>.--There is no definitive nationwide analysis of nonpoint source water quality problems. However, estimates in EPA's "National Water Quality Inventory, 1977 Report to Congress" indicate that nonpoint source pollution is a significant concern (EPA, 1978). For this report, many states estimated the nonpoint source loadings of various pollutants. The report of the National Commission on Water Quality (1976) also contained some estimates of the relative magnitude of point source and nonpoint source loadings for a few pollutants. These reports indicate that nonpoint sources contribute significantly greater loadings of some pollutants, especially suspended solids, than do point sources. However, this

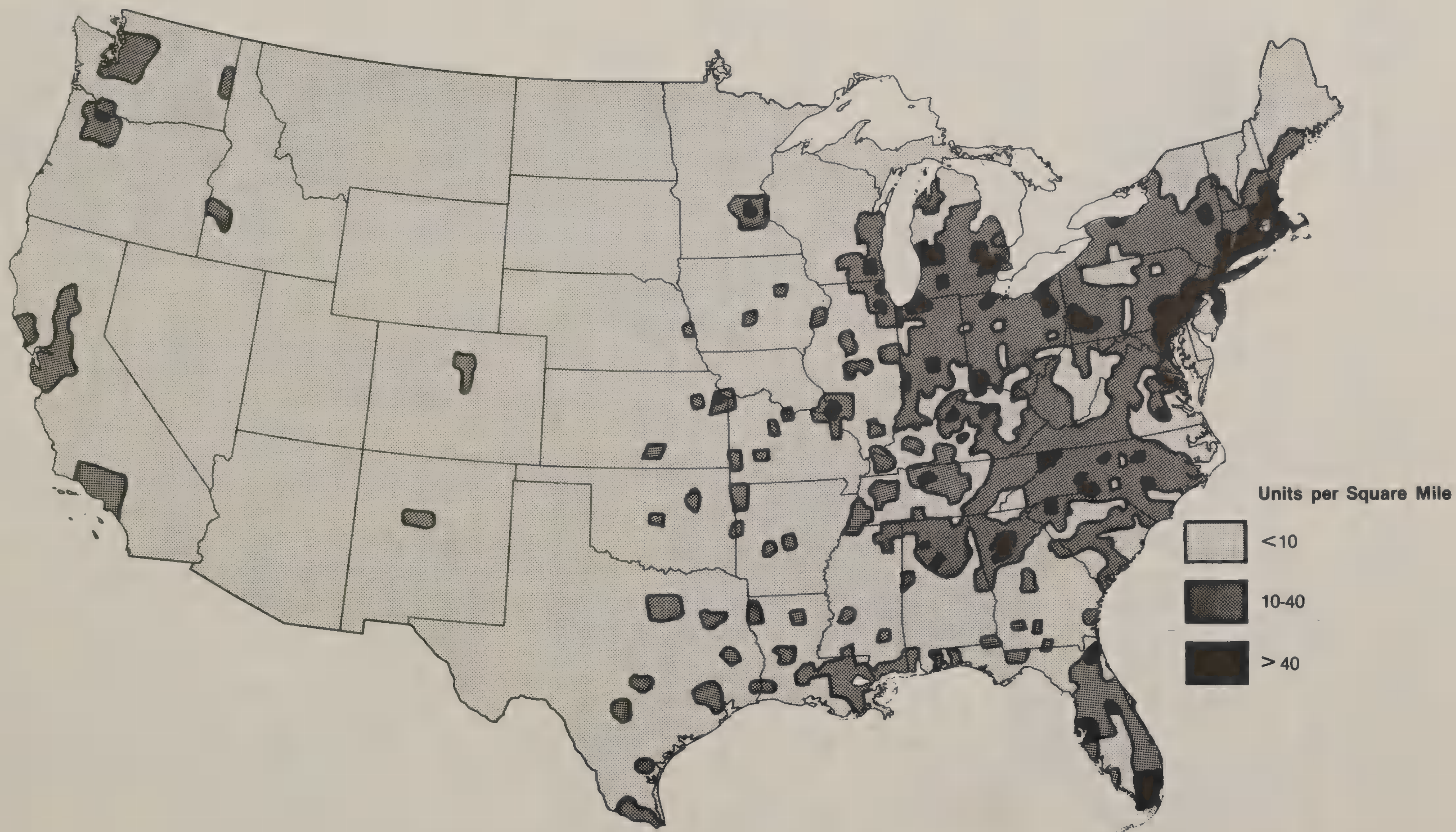


Figure 3B-16.--Density of dwellings using onsite domestic waste disposal systems, by county. Source: Environmental Protection Agency. 1977. Environmental effects of septic tank systems. (EPA Publ. 600-3-77-096)

Table 3B-6.--Estimated household septage generation, by state 1/

(Millions)

State	Cubic meters per year	Gallons per year	State	Cubic meters per year	Gallons per year
Alabama----------	0.36	96.3	Montana-----------	0.07	18.5
Alaska-----------	0.02	4.7	Nebraska----------	0.10	26.3
Arizona----------	0.11	28.6	Nevada------------	0.02	5.5
Arkansas---------	0.21	55.1	New Hampshire------	0.10	27.3
California--------	0.81	213.3	New Jersey---------	0.38	101.1
Colorado---------	0.11	28.3	New Mexico---------	0.06	16.4
Connecticut-------	0.34	88.6	New York----------	1.22	322.3
Delaware---------	0.00	1.0	North Carolina-----	0.65	171.9
Washington, D.C.--	0.00	0.11	North Dakota-------	0.05	13.3
Florida----------	0.89	234.5	Ohio--------------	0.74	194.9
Georgia----------	0.45	118.6	Oklahoma----------	0.19	50.8
Hawaii-----------	0.05	12.6	Oregon------------	0.26	69.0
Idaho------------	0.09	23.3	Pennsylvania-------	0.93	246.3
Illinois---------	0.52	138.7	Rhode Island-------	0.10	25.9
Indiana----------	0.56	147.4	South Carolina-----	0.32	83.6
Iowa-------------	0.24	64.5	South Dakota-------	0.06	15.6
Kansas-----------	0.16	41.0	Tennessee---------	0.43	114.3
Kentucky---------	0.30	78.2	Texas-------------	0.62	163.6
Louisiana--------	0.27	71.9	Utah--------------	0.05	12.3
Maine------------	0.13	35.1	Vermont-----------	0.06	17.1
Maryland---------	0.23	60.9	Virginia----------	0.39	102.1
Massachusetts-----	0.46	122.6	Washington---------	0.38	101.0
Michigan---------	0.80	211.9	West Virginia-------	0.18	46.8
Minnesota--------	0.29	76.9	Wisconsin----------	0.36	92.9
Mississippi-------	0.20	52.3	Wyoming------------	0.02	5.8
Missouri---------	0.34	89.8			
			Total---------	15.67	4,141.91

1/ Based on pumping a 1,000-gallon septic tank every 4 years.

type of data should not be the sole criterion for assessing the relative effects of nonpoint and point source pollution. The state of Florida, while recognizing the importance of nonpoint source problems, points out the following with regard to its own nonpoint source loading estimates (EPA, 1977):

> Nonpoint sources, in contrast to point sources, are generally diffused and may be more readily assimilated by the receiving waters than the more concentrated point source loads. In addition, nonpoint loads are generally released as pulse loads during rainfall events and any associated violations of water quality standards may be of an intermittent rather than continuing nature. Hence, while estimates of total nonpoint pollution loads are necessary to support the evaluation of water quality problems, more thorough analysis will be necessary to determine the relative contributions of point and nonpoint loads to specific problem areas.

Much of the nonpoint source pollution results from agricultural activities (EPA, 1978). Sixty-eight percent of the basins in the United States report water pollution caused by agricultural activities (tables 3B-7 and 3B-8). The North Central, South Central, and Southwest Regions, the Hawaiian Islands, and Puerto Rico are most seriously affected by agriculture and silviculture (figs. 3B-17 and 3B-18). In these regions, pollution caused by agricultural activities affects 85 percent of the basins, compared to an average of only 58 percent in the rest of the country. The amount of ground water and the number and acreage of lakes significantly affected by nonpoint source pollution is unknown. In the Second National Water Assessment most regions reported some form of ground water contamination (figure 3B-19) (USWRC, 1978). A 1977 General Accounting Office report stated that "agricultural nonpoint source pollution, if not controlled, will prevent attainment of the national water quality goals and will continue to grow in significance as point sources are brought under control" (GAO, 1977).

As more food and fiber are grown to meet increasing domestic and foreign demand, the use of pollution-causing materials will increase (for example, fertilizer, animal and other wastes, pesticides, and irrigation water). In addition, more marginal land is likely to be used and farming such land produces more agricultural nonpoint source pollutants. This situation will worsen if the Nation continues to lose potential prime farmland to competitive uses and farmers turn more to marginal land.

The effects of potential agricultural pollutants are described in the following paragraphs (USDA, 1978).

- Pesticides.--In the United States, more than 1,800 biologically active compounds are sold in more than 32,000 different formulations. The use of chemicals, particularly herbicides, to control crop pests and undesirable vegetation has increased sharply in the last three decades and is still rising. In 1971, more than 158 million acres of land were treated with herbicides, 65 million acres with insecticides, and 7.5 million acres with fungicides. Farmers used about 60 percent of the 750,000 tons of pesticides produced in 1977. Although there has been a decline in pesticide use recently, the number of acres farmed is

Table 3B-7.--Percentage of basins wholly or partly affected by nonpoint source pollution, by source

Region (number of basins)	Urban runoff	Con-struction	Hydrologic modifi-cation	Silvi-culture	Mining	Agri-culture	Solid waste disposal	Individual disposal
	(Percent)							
Northeast (40)	70	15	20	10	20	55	35	63
Southeaster (47)	57	2	21	30	15	62	9	40
Great Lakes (41)	54	7	2	15	41	59	15	39
North Central (35)	54	6	3	6	40	39	9	29
South Central (30)	50	0	23	13	53	87	13	40
Southwest (22)	23	0	18	5	36	73	0	35
Northwest (22)	23	23	23	27	23	55	9	32
Islands (9)	67	67	22	0	0	78	22	89
Total	52	9	15	15	30	68	14	43

Table 3B-8.--Percentage of basins wholly or partly affected by nonpoint source pollution, by pollutant

Region (number of basins)	Bacteria	Oxygen depletion	Nutrients	Sus-pended solids	Dis-solved solids	pH	Oil and grease	Toxics	Pesti-cides
	(Percent)								
Northeast (40)	70	53	63	65	10	18	15	33	18
Southeast (47)	66	74	57	34	4	9	4	11	23
Great Lakes (41)	51	54	44	56	27	37	20	34	15
North Central (35)	69	66	63	80	51	20	0	51	37
South Central (30)	53	43	63	37	70	23	3	47	40
Southwest (22)	36	14	45	32	68	14	14	27	0
Northwest (22)	64	18	55	64	14	9	5	32	0
Islands (9)	89	44	44	100	0	0	0	22	44
Total	61	51	56	54	30	18	9	32	22

Figure 3B-17.--Basins wholly or partly affected by pollution from agriculture. (Affected basins are shaded.) (EPA, 1978)

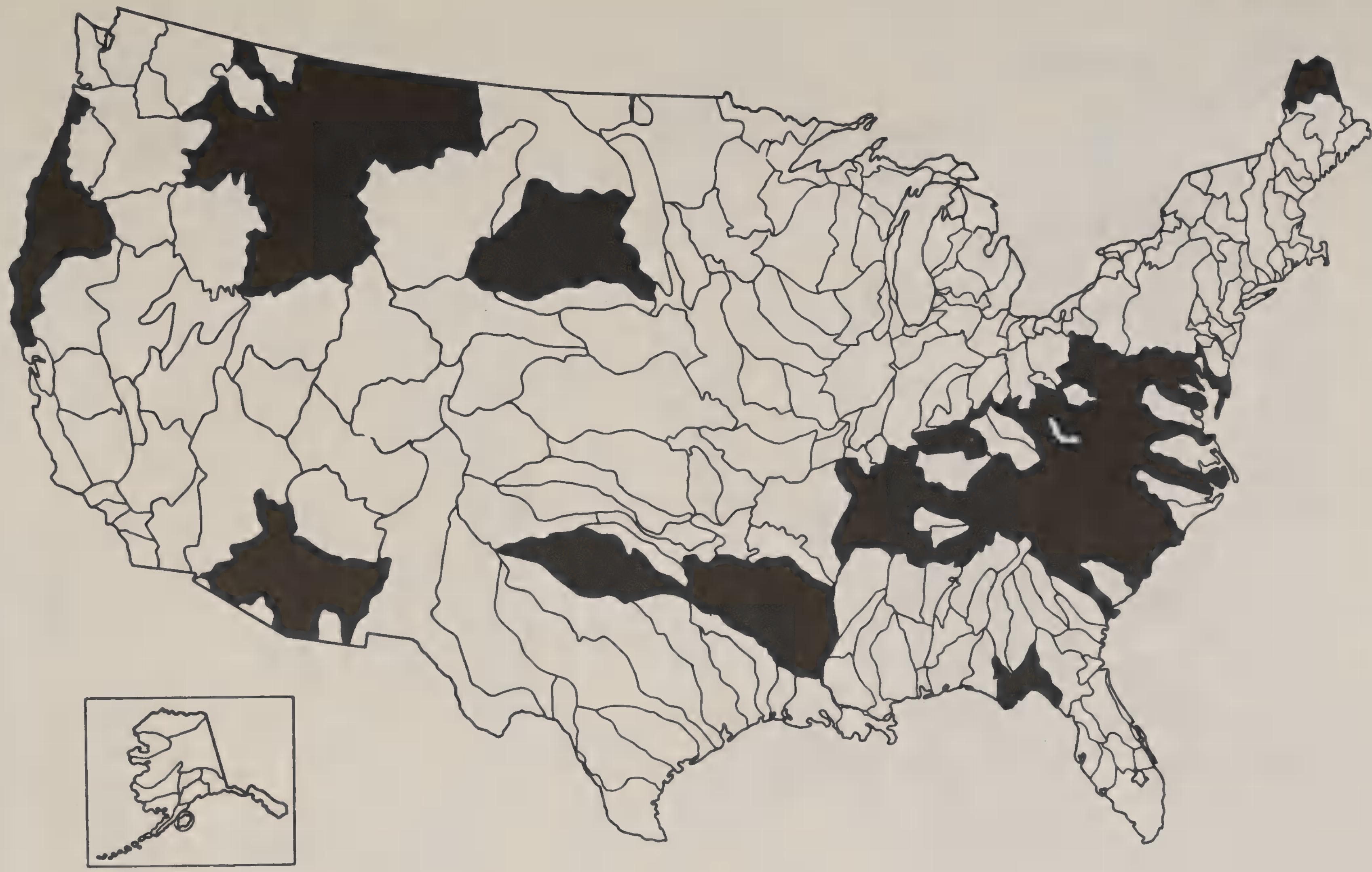


Figure 3B-18.--Basins wholly or partly affected by pollution from silviculture. (Affected basins are shaded.) (EPA, 1978)

Area problems

- Significant ground-water pollution is occurring
- Salt-water intrusion or ground water is naturally salty
- High level of minerals or other dissolved solids in ground water
- Unshaded area may not be problem-free, but problem was not considered major

Specific sources of pollution

- ● Municipal and industrial wastes including wastes from oil and gas fields
- ♦ Toxic industrial wastes
- ▲ Landfill leachate
- ■ Irrigation return waters
- ▬ Wastes from well drilling, harbor dredging, and excavation for drainage systems
- ★ Well injection of industrial waste liquids

Figure 3B-19.--Ground water pollution problems as identified by federal and state regional study teams. (USWRC, 1978)

expected to increase and farmers are projected to use 1.25 million tons of pesticides in 1985.

Many investigations have found agricultural pesticides in runoff from treated land. Nearly all come to the same general conclusions. Concentrations are very low except when heavy rainfall occurs directly after treatment. Generally, less than 5 percent of the total amount of pesticides runs off the land during the crop year. Nevertheless, some of these pesticides are highly toxic to fish or other aquatic life. Many persist in the aquatic environment for a long time, so even very low levels of these pesticides are of concern.

o Nutrients.--Farmers used about 49 million tons of commercial fertilizers during the fiscal year ending June 30, 1976. These fertilizers contained roughly 20 percent nitrogen, 5.2 percent phosphorus, and 8.8 percent potassium. Nitrogen and phosphorus residues can enter surface and ground waters in runoff and through leachate losses from animal wastes, commercial fertilizer, and crop residue. They can also enter surface waters with sediment. About 750,000 tons to 7.5 million tons of nitrogen and about 60,000 tons to 600,000 tons of phosphorus enter the Nation's waters from all agricultural sources each year.

The amount of nitrogen and phosphorus entering surface and ground water from cropland depends on the application rates of fertilizer, soil properties, the amounts coming from natural sources, terrain, crop management, and rainfall. Many experiments have determined the amount of nitrogen and phosphorus lost to waters under particular agricultural conditions. The percentage of total applied nitrogen that reaches surface waters ranges from about 15 to 54 percent. Total applied nutrients range from 0.03 pound to 8.4 pounds per acre of nitrogen and from 0.01 to 0.08 pound per acre of phosphorus.

Nutrients are also contained in runoff and leachate from animal wastes. These wastes are contained in confined units or spread on land. The loss varies by geographic area, size and type of confinement unit, and type of waste disposal system. If wastes are properly disposed of, confined housing of animals minimizes potential pollution. Feedlots are the most severe potential polluters. In some small areas, fish farming may contribute significant amounts of nutrients to receiving waters.

o Bacteria and organic material.--Livestock produce about 1.2 billion tons of wastes annually. Unconfined animal operations use about 40 percent of the Nation's land and produce about 50 percent of all livestock wastes. When not properly managed, these operations can change the composition of the plant cover and the physical properties of the soil. Such changes can increase runoff and facilitate the movement of pollutants to surface waters. These pollutants can elevate the counts of indicator bacteria in water. Inadequate livestock management and poor site conditions can also increase the levels of inorganic and organic sediments and their associated nutrients and oxygen-demanding materials.

o Sediment.--About half of the sediment delivered to streams and lakes comes from cropland (table 3B-9). Sediment deposited in water bodies can cover fish spawning areas, clog river channels, fill lakes, reduce

light transmission in water, and carry absorbed pesticides and nutrients. Fine-grained particles of soil and organic matter, are highly susceptible to erosion. They are of particular concern because they are likely to transport available pesticides and they can pass through many erosion and sediment control measures. The level of sediment in streamflow depends on erosion rates, sediment delivery ratios (see glossary), and the density of the plant cover.

- Salinity.--About 58 million acres, or about 14 percent of the cropland in the United States, are irrigated. The value of crops produced on irrigated land is about 25 percent of the total value of the Nation's crops. About 90 percent of the irrigated land is in the 17 states farthest west (excluding Alaska and Hawaii).

  The effect of agricultural irrigation on water quality has received major attention only recently. The most significant water quality problem that irrigation causes is high salinity. However, irrigation also contributes to the levels of other pollutants, such as pesticides, nutrients, and sediment. Leaching of saline soils (both surface and subsurface), evaporation, and transpiration are the primary causes of increased salinity from irrigation.

Table 3B-9.--Estimated percentage of sediment from different sources

Sediment source	Contribution
	(Percent)
Cropland----------------------------	40
Streambanks-------------------------	26
Pasture and rangeland---------------	12
Forest lands------------------------	7
Urban-------------------------------	4
Roadsides---------------------------	3
Mining------------------------------	1
Other-------------------------------	7
Total-------------------------	100

  Salinity cannot be easily reduced because much of the salt in water comes from natural sources. However, water conservation practices that reduce seepage and deep percolation from irrigation and practices that reduce incidental consumptive losses can significantly reduce salt loading. Existing technology to promote efficient irrigation includes improved water delivery systems, onsite irrigation management, and improved application systems and return flow management.

  Water percolation contributes significantly to salt loading in western streams because it leaches considerable amounts of minerals or salts from saline soils. Salinity is significant in about 20 percent of the soils in the western states. Erosion in high salt areas, including shales and lakebed deposits, contributes large amounts of salt to

streams. Erosion contributes to the 90 to 100 million tons of salt that degrade the water supplies in the 11 western states annually. Erosion control in these areas could reduce salt loads by more than 2 million tons per year.

Salinity caused $53 million in damage in the Colorado River system in 1973. By the year 2000, this damage is expected to reach about $124 million if no control measures are applied. The Bureau of Reclamation recently estimated direct and indirect economic losses at about $230,000 for each increase of 1 mg/l in salinity at the Imperial Dam.

Silvicultural Nonpoint Sources.--Most states indicate that they do not have enough data to determine the exact extent of pollution from silviculture, particularly from logging activities. Available data do not show that silvicultural activities contribute heavily to water quality problems. However, there are local problems caused by poorly located and constructed logging roads and skid trails and by poor management in clearing or preparing sites. In problem areas, runoff causes sedimentation and can also add oxygen-demanding material, nutrients, and pesticides to the water. Pollution problems from silviculture occur primarily in the Southeast and Northwest Regions (see table 3B-7 and figure 3B-18).

Sediment is the primary pollutant from silviculture. However, sediment from silviculture is less than 4 percent of the man-caused sediment in the Nation's water. Although chemical runoff from forest lands can be a local problem, less than 2 million acres, or 0.3 percent of the Nation's forests, receive chemical treatment each year.

Water from forest land is generally of high quality and suitable for the most sensitive water uses. For example, almost all western cities and most eastern cities have municipal water supplies in forested areas, and trout and salmon fisheries depend on high quality water from forested watersheds.

Fifteen states are responsible for 81 percent of the problems related to silviculture. In those states, 21 percent of the forest is public land, 28 percent is owned by the forest industry, and 51 percent is in small woodlots. Diverse ownership and the intermingling of private and public lands contribute to the complexity of the problem. Of these fifteen states, five have forest practices acts and four control some silvicultural activities through other legislation, such as laws on sediment, erosion control, and streambanks.

Specific examples of severe nonpoint source pollution from silviculture follow (EPA, 1979b).

- Oregon has identified seven priority areas having water quality problems related to silviculture (the southwest part of the North Coast Basin, the Yamhill River, the South Fork of the Umpqua River, part of the Goose/ Summer Lakes Basin, and the Crooked, Malheur, and Umatilla Rivers). The water quality problems in these areas are erosion and sedimentation, excessive debris, high water temperatures, and growths of algae.

- Washington has six priority areas with water quality problems (Willapa Bay, the Kaloma River, part of the Skykomish River, part of the Sno-

homish River, and the Newaukum and Deschutes Rivers). The problems are sediment, temperature, and slash or debris.

- Maine's survey of 350 sites indicated that 10 percent have sediment problems affecting parts of streams and 25 percent have excessive erosion. In addition, the spraying of sevin to control spruce budworm has killed fish.

Abandoned Mines.--The United States has 1.7 million acres of abandoned coal mine lands that need reclamation. This acreage is in 30 states; 97 percent is in 14 states. Water quality in these areas is degraded when silt, sediment, and chemical pollutants move from the mined areas into surface water.

Mining operations denude land, eliminate wildlife habitat, and destroy soil in the immediate area, but the effects of water pollution from mining may be apparent many miles from the mining operation. Extensive reaches of streams can be rendered unsuitable for domestic and industrial water supplies and for agricultural uses, such as irrigation. The polluted water can kill fish and other aquatic life, and drainage from surface mines can cross adjacent lands, destroying crops and trees and ruining wells and lakes. Abandoned coal mine lands degrade water wherever they exist; however, the greatest water pollution problem is in the East. Surface mining has degraded the water in about 6,000 miles of streams and 68 reservoirs (Spaulding and Ogden, 1968). More than two-thirds of the affected streams are in Pennsylvania and West Virginia. The lower runoff in the West may intensify problems in particular locations.

Mine water often contains high concentrations of acid and such minerals as aluminum and calcium. Iron hydroxide ("yellow boy"), which coats stream bottoms, is formed as these acids and minerals interact with the water. Spaulding and Ogden indicated that chemical precipitates were on the stream bottoms in 31 percent of the sites, and the water was discolored in 37 percent. Silt and sediment pollution are common in all areas of surface mining. As water flows over loose soil or rocks, it picks up and carries small particles. These particles settle out in watercourses where they cause additional problems.

Spaulding and Ogden found that 15,000 acres of water impoundments in 20 states could provide suitable fish and wildlife habitat if acid pollution were sufficiently reduced. Coal mining caused about 97 percent of the acid pollution in streams and 63 percent of the acid pollution in water impoundments.

The U.S. Public Health Service estimated in 1962 that active and abandoned underground and surface mines in Appalachia discharged 3.2 million tons of acid into streams each year. Much of this acid is neutralized soon after it enters the stream, but a residual acid load of more than 300,000 tons a year is not neutralized until it reaches the larger streams of the region.

USDI studies (1967) indicate that sediment is caused mostly by inadequate plant cover. They also showed that of 14,000 miles of stream channels affected by surface mining, 7,000 miles had a significantly reduced water-carrying capacity and 4,500 miles had a moderately reduced capacity. Excess sediment from mine activity was not found, however, in small streams

that were more than 2 miles from the mined area. On 98 percent of the surface-mined land in Appalachia, where contour strip mining is common, storm water control is not adequate to prevent erosion, sedimentation, or flooding.

Trends.--Figures 3B-20 through 3B-23 show trends in the level of total coliforms, nitrates, phosphorus, and dieldrin in sediment. Although these data are not complete and do not differentiate between point and nonpoint sources, they do show that in many areas the levels of total coliforms are decreasing; levels of nitrates are increasing, especially in agricultural areas; and levels of sediments containing dieldrin show a slight decrease since that pesticide was banned. Overall, while some improvement is presumably occurring from the cleanup of point sources, increasing urbanization and agricultural production are increasing nonpoint source pollution. Although definitive information on national nonpoint source loadings does not exist, existing information show problems from agricultural nonpoint source pollution.

Figures 3B-24 through 3B-26 show areas of potential agricultural nonpoint source pollution based on the intensity of a particular agricultural activity. See also figures 5B-3 through 5B-7 on pages 5-30 and 5-31 of RCA Appraisal Part I. Those figures show the extent of specific agricultural nonpoint source pollutants nationwide.

Specifc examples of the severity of agricultural nonpoint source pollution follow (EPA, 1979b).

- Maine.--The state has identified nine lakes and portions of three rivers (the Aroostook, St. Johns, and Prestile) as having significant water quality problems (coliform bacteria, dissolved oxygen, nutrients, and sediment) attributable to agricultural nonpoint source pollution. This pollution comes from dairy and poultry farms, cropland, and rural septic systems. Specific violations of water quality standards for coliform bacteria and dissolved oxygen have been documented on some lakes.

- Connecticut.--The state determined that agricultural erosion statewide was more than 12 tons per acre per year (an acceptable value is generally 3 to 5 tons per acre per year). The resulting sediment contributes to agricultural nonpoint source pollution, especially in Lake Waramaug and the Housatonic River. This situation is interfering with recreation and impairing water supplies.

- Massachusetts.--Rural nonpoint source pollution is causing eutrophication in several lakes and reservoirs in Berkshire County, which is critical because of water supply and recreation demands of the tourist industry. Nonpoint source pollution accounts for 60 to 90 percent of the nutrient loadings to these lakes. Levels of nutrients, coliform bacteria, and dissolved oxygen have violated water quality standards.

- Delaware.--Rural nonpoint source pollution from agriculture, animal wastes, and rural septic systems is causing nitrate problems in underground drinking water supplies in the Millsboro area of Sussex County. Sixty to 100 mg/l of nitrates are present in the water, far above the standard of 10 mg/l.

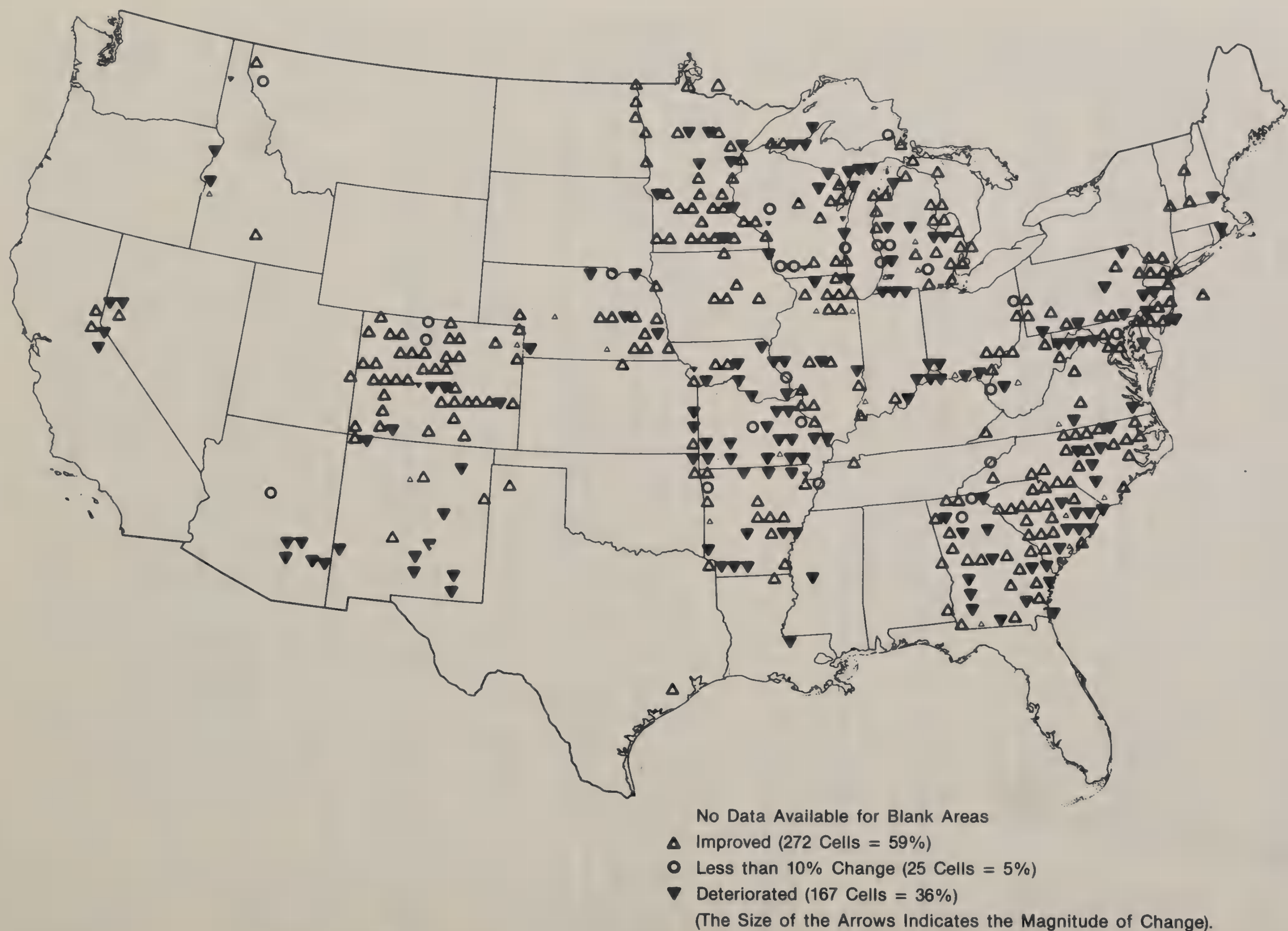


Figure 3B-20.--Trends in levels of fecal coliform bacteria, 1967-69 to 1973-75. Source: EPA STORET system, 1976.

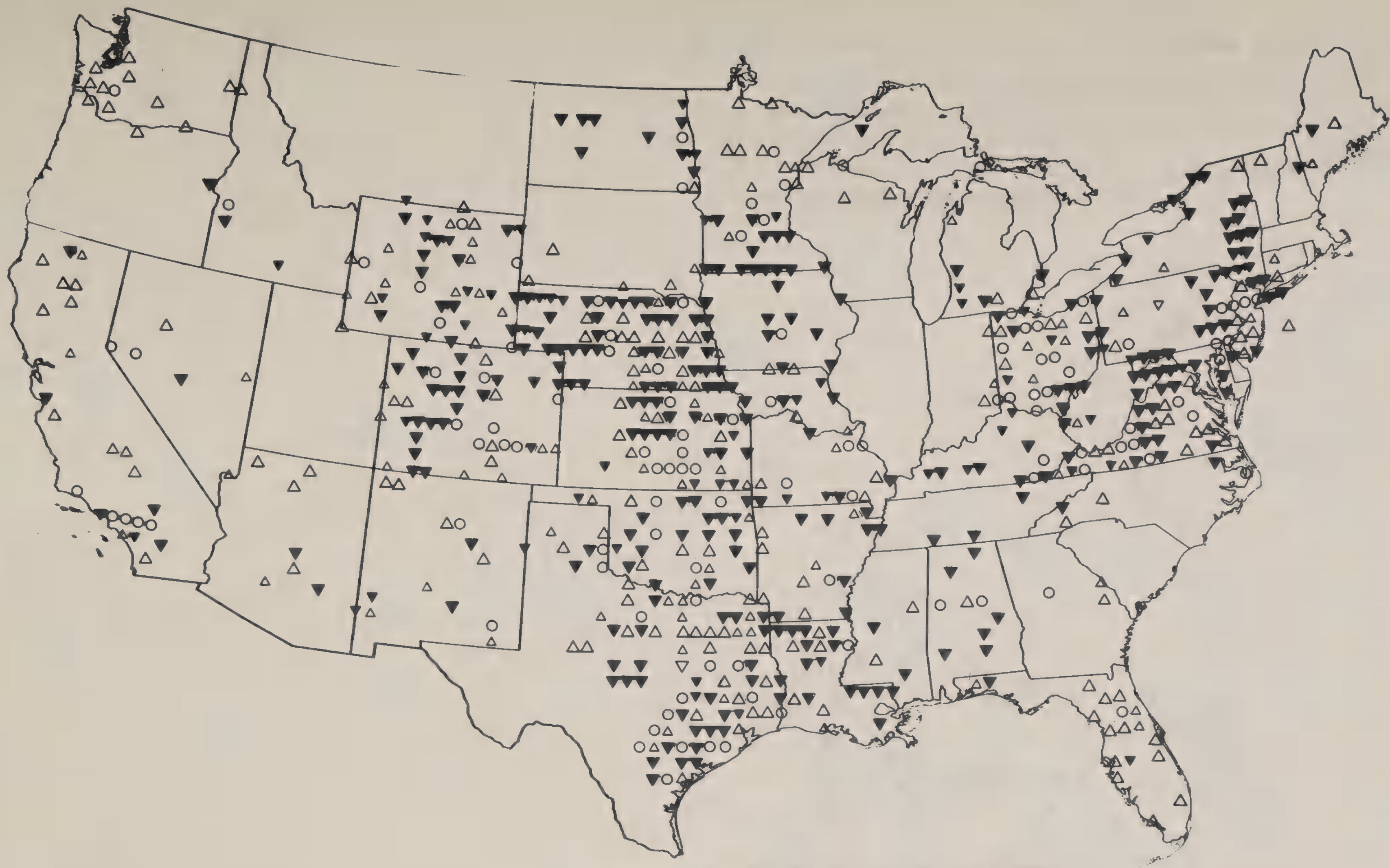


Figure 3B-21.--Trends in levels of nitrates, 1967-69 to 1973-75, 85th percentiles. The trend is the difference in water quality values over time. The 85th percentile means that 85 percent of the samples from any cell have a specific value or less. Source; EPA STORET system, 1976.

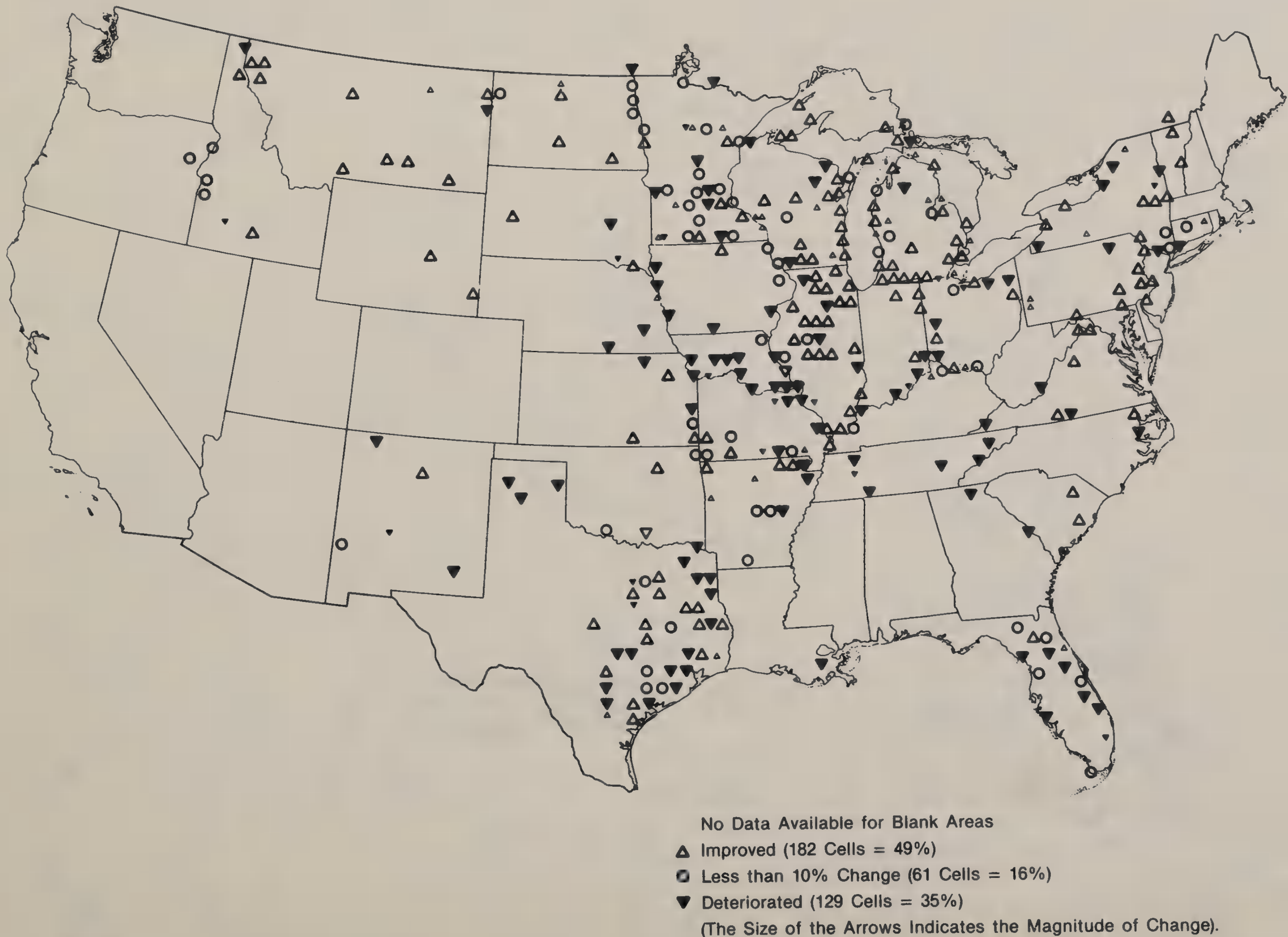


Figure 3B-22.--Trends in levels of phosphorus, 1967-69 to 1973-75. Source: EPA STORET system, 1976.

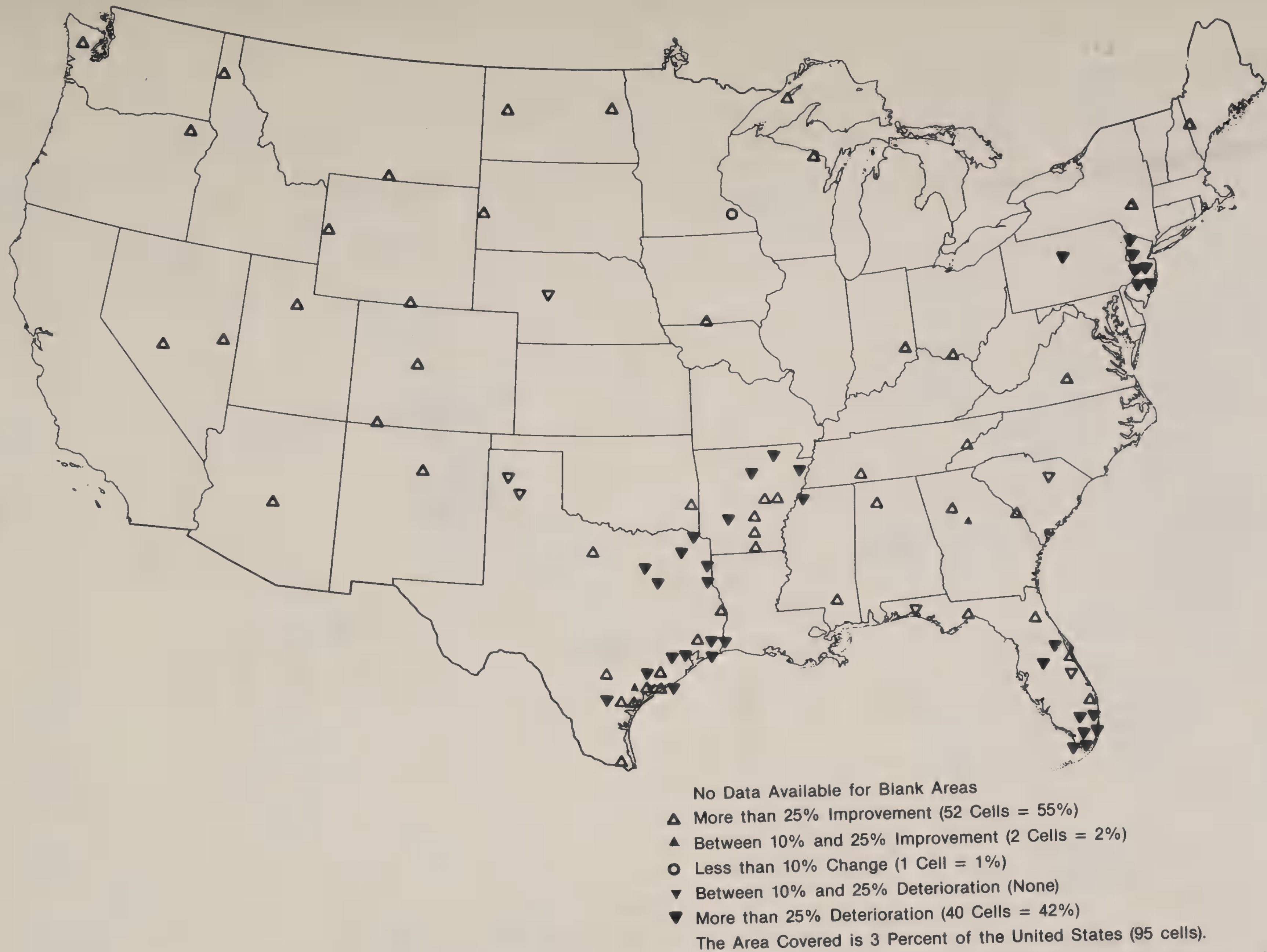
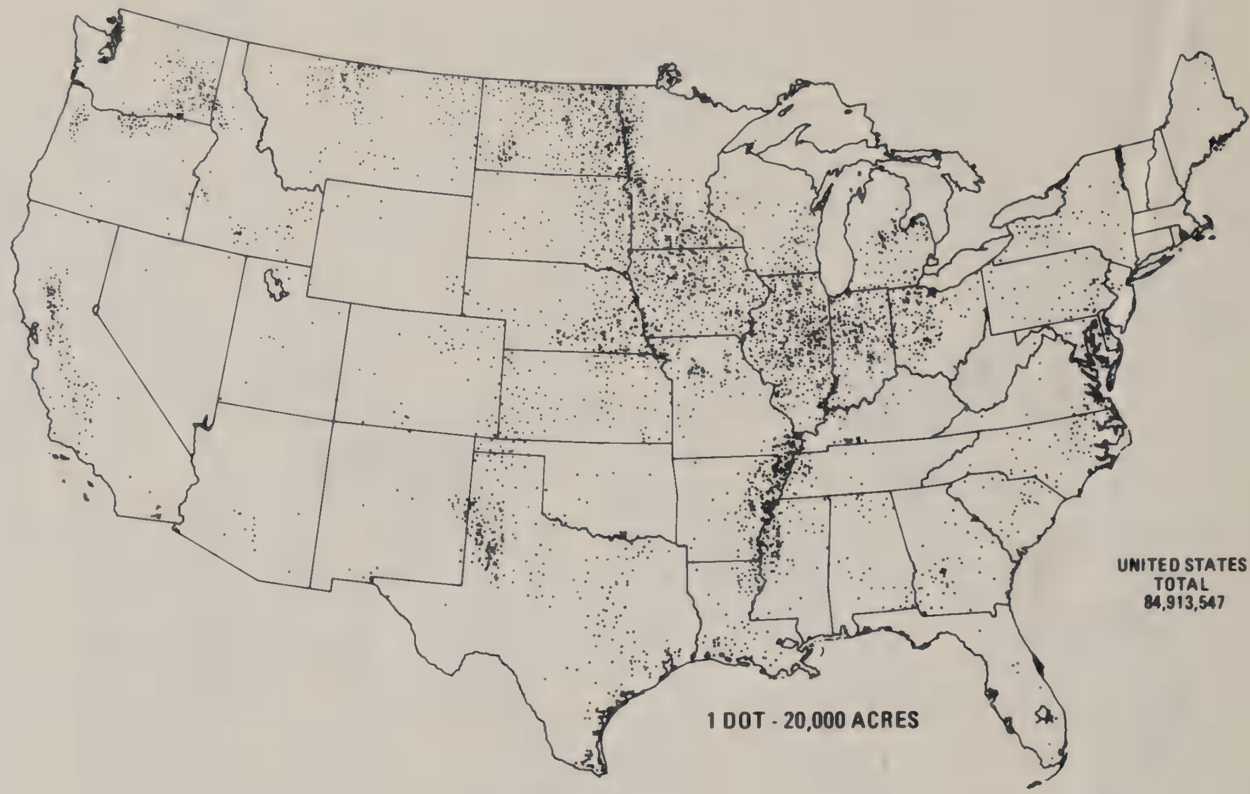


Figure 3B-23.--Trends in levels of dieldrin in sediment, 1966-70 to 1971-76, 85th percentiles. The trend is the difference in water quality values over time. The 85th percentile means that 85 percent of the samples from any cell have a specific value or less.



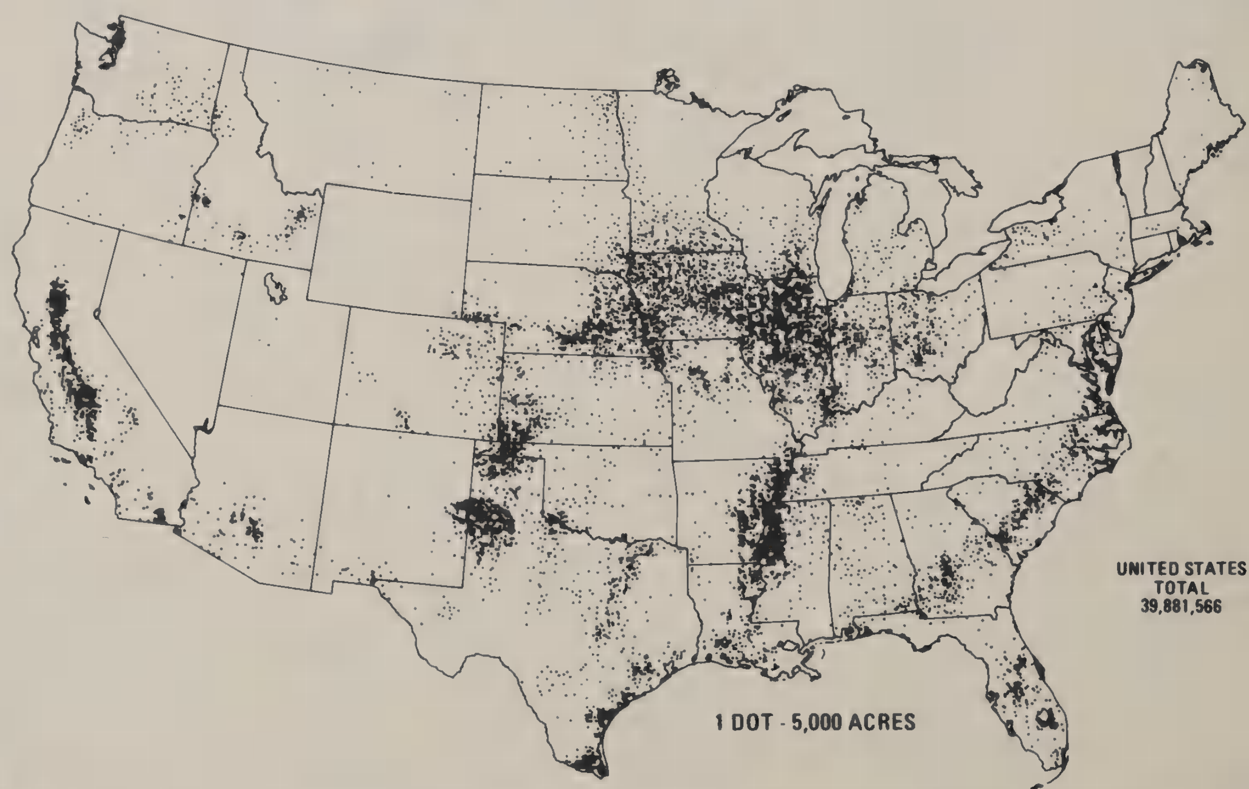
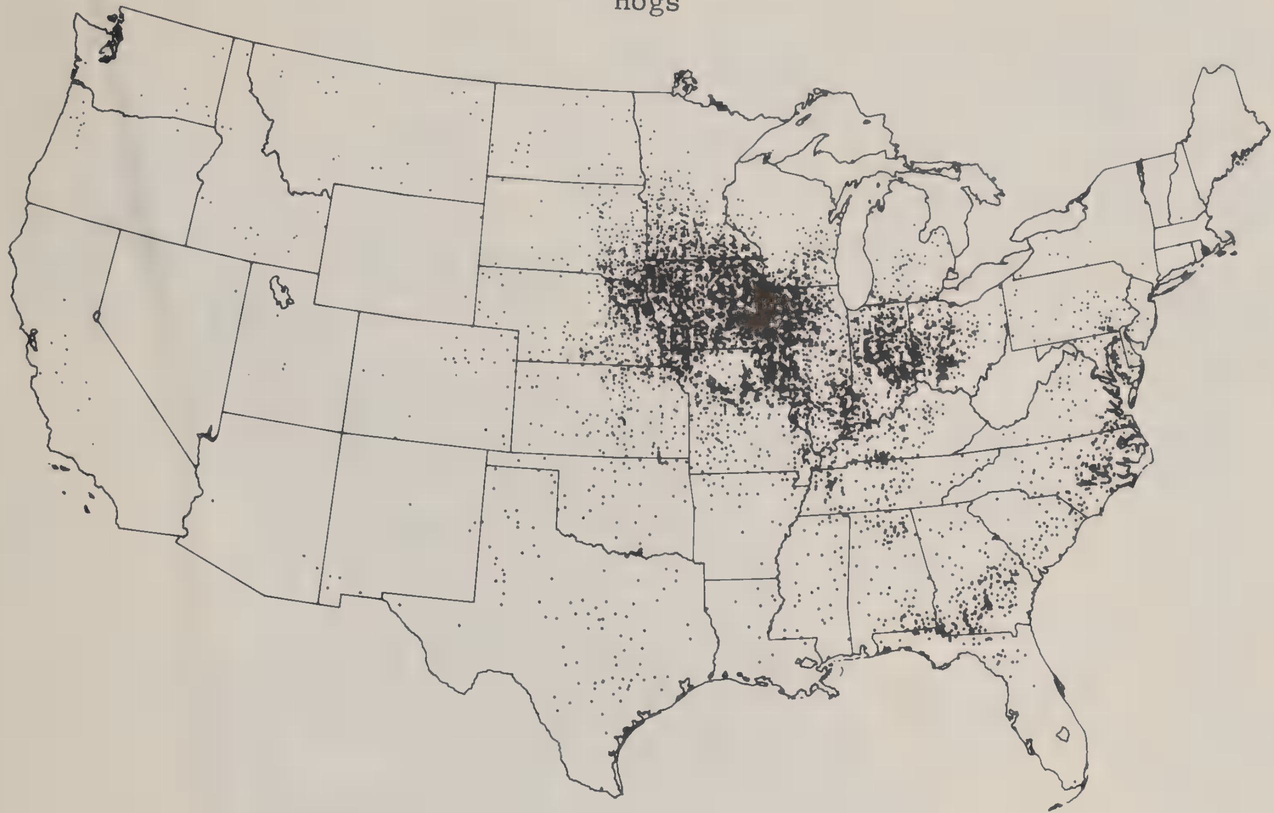


Figure 3B-24.--Cropland treated with herbicides (top) and insecticiaes (bottom), 1969. Source: United States Department of Agriculture and Environmental Protection Agency. 1975. Control of water pollution from cropland. Vol. I. A manual for guideline development.

Hogs



Chickens

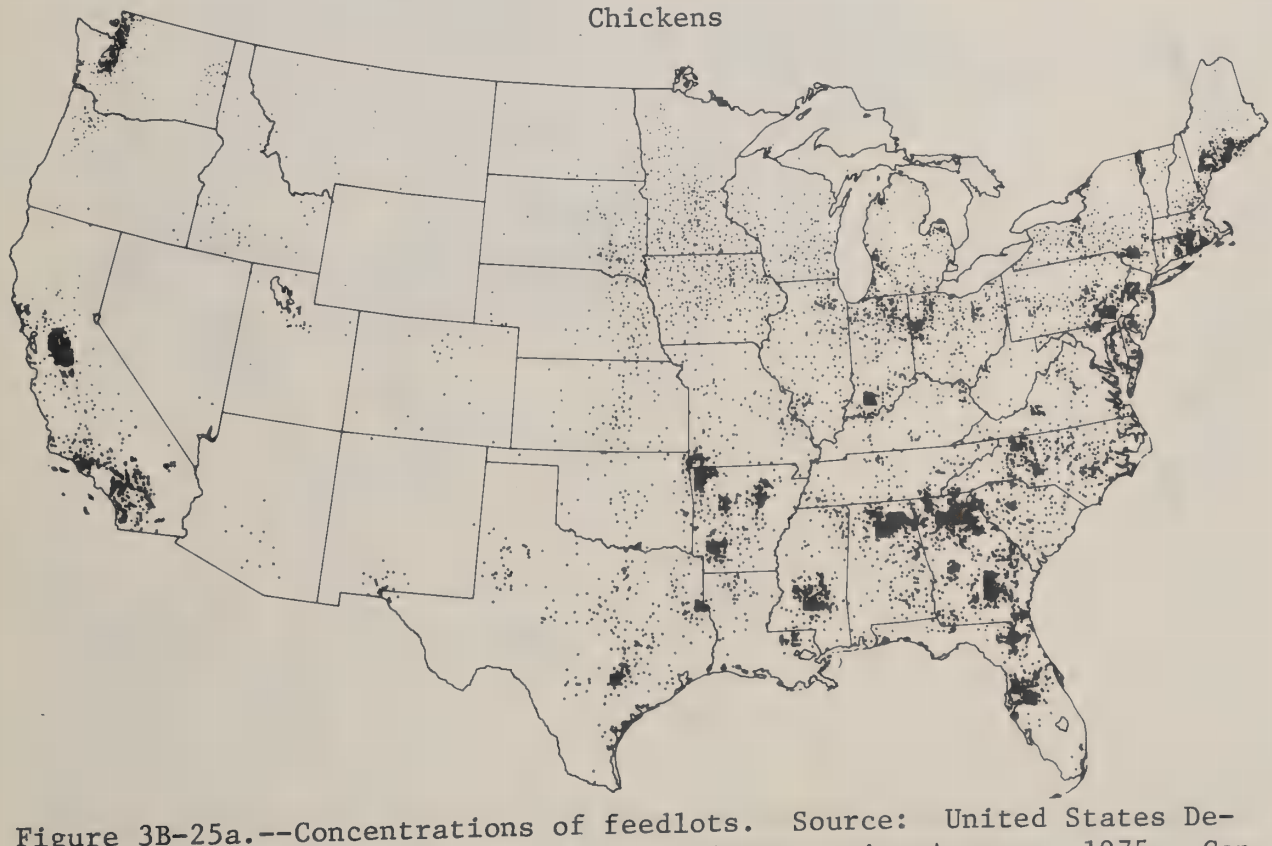
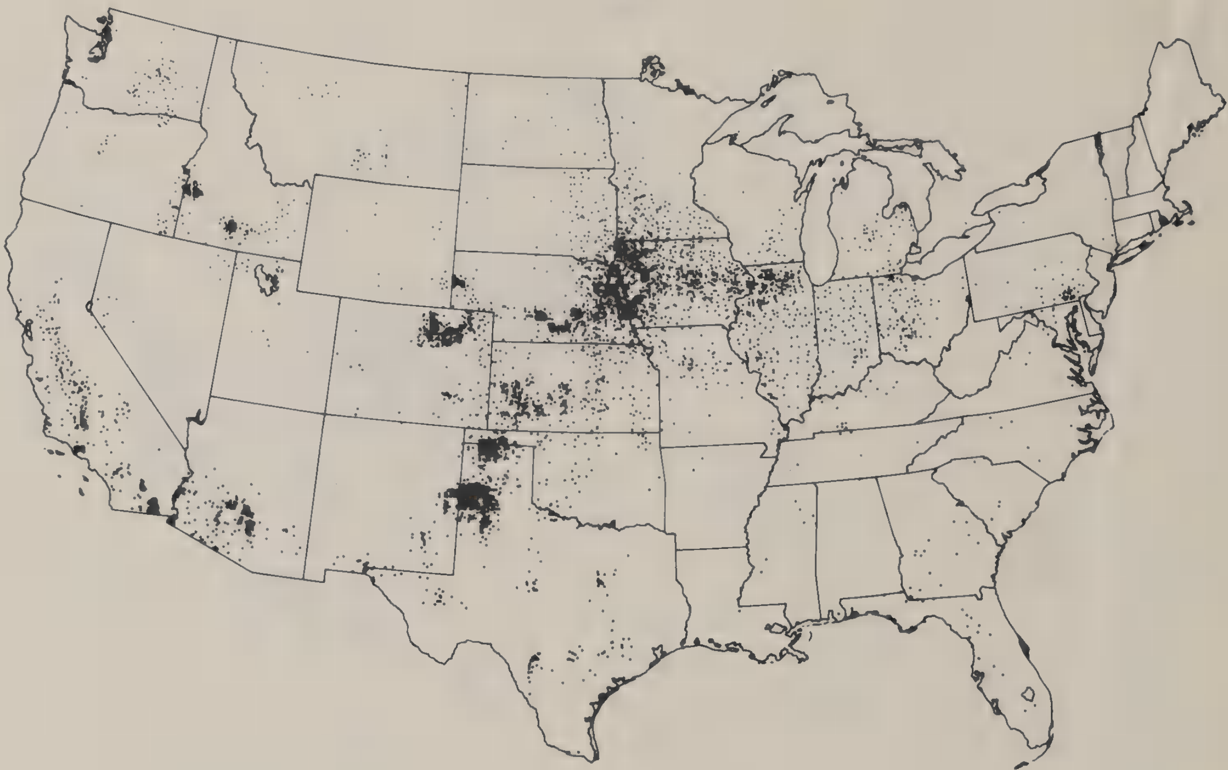


Figure 3B-25a.--Concentrations of feedlots. Source: United States Department of Agriculture and Environmental Protection Agency. 1975. Control of water pollution from cropland. Vol. I. A manual for guideline development.

Beef



Dairy Farms

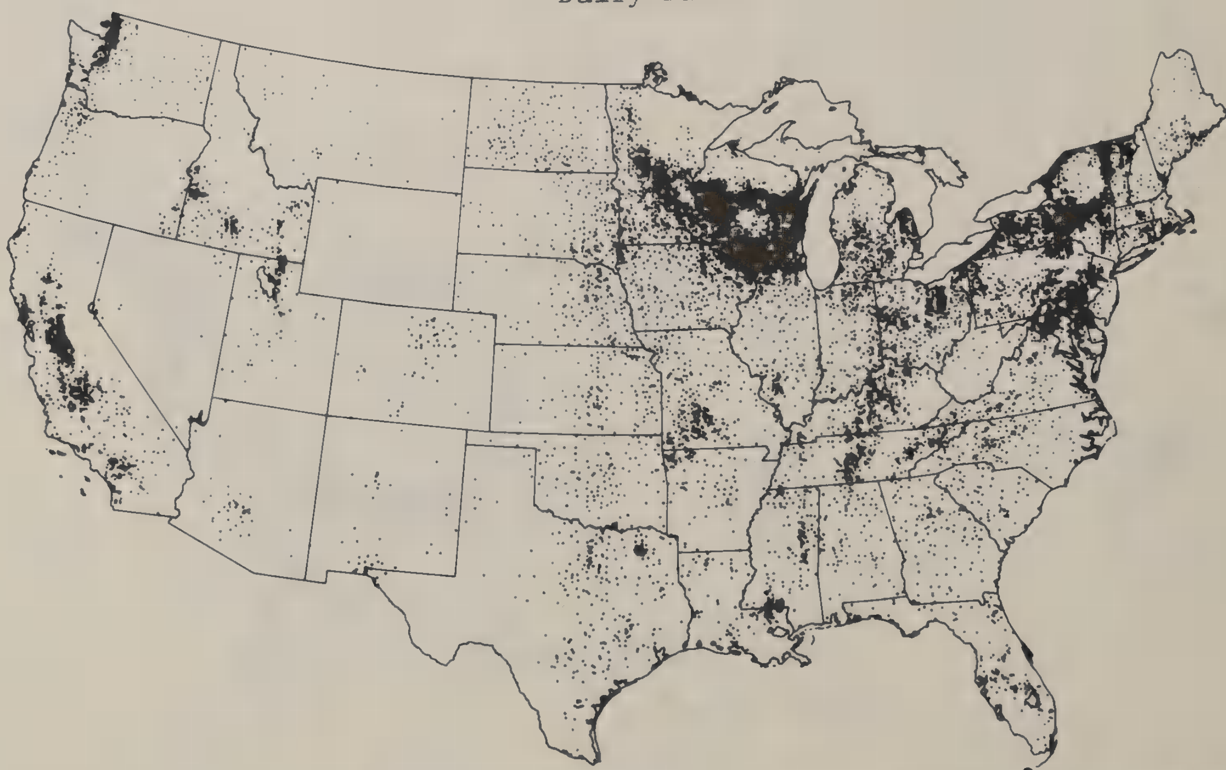


Figure 3B-25b.--Concentrations of feedlots. Source: United States Department of Agriculture and Environmental Protection Agency. 1975. Control of water pollution from cropland. Vol. I. A manual for guideline development.

Figure 3B-26.--Relative potential contribution of cropland to sediment in watersheds. Source: United States Department of Agriculture and Environmental Protection Agency. 1975. Control of water pollution from cropland. Vol. I. A manual for guideline development.

- Virginia.--Agricultural and urban runoff is contributing to eutrophication in the Occoquan Reservoir (the drinking water supply for 700,000 people). The eutrophication may negate benefits of the very expensive advanced water treatment plant feeding into the reservoir.

- Maryland.--Runoff containing animal wastes and other agricultural pollutants is causing violations of coliform bacteria levels in several rivers in northeast Maryland; in Carroll, Frederick, and Howard Counties; and in Lock Raven and Liberty Reservoirs.

- North Carolina.--Average nitrogen levels of 7 mg/l and average levels of dissolved oxygen of 0 mg/l, probably the result of runoff from livestock operations, were found in Union County on a creek tributary to Lane Creek. The fish in this creek were dead. Fish killed by herbicides were also found in Richardson Creek and Twelve Mile Creek. Some areas have erosion rates of 20 to 60 tons per acre per year. Dissolved oxygen concentrations in the upper Neuse River fell to about 1 mg/l during certain storm conditions. During all storms measured, there were high concentrations of suspended solids in both the small streams and large rivers. The Chowan River has experienced severe algal blooms, which affect fisheries, ruin beaches, and cause objectionable odors and deposits of decaying algae. About 85 percent of the nitrogen in the water in North Carolina is from nonpoint sources with agricultural areas accounting for about half of that amount.

- Tennessee.--High phosphorus and nitrogen loadings from agricultural land have made the Chickamauga and Nickajack Reservoirs eutrophic. Algal blooms preclude recreation in certain areas.

- Arkansas.--In one intensively studied basin, 2 million tons of sediment reached the water each year. Out of 60 streams in this basin, 47 were not suitable for swimming and 37 were not suitable for fishing because of agricultural nonpoint source pollution. Streams in eastern Arkansas have excessive levels of the pesticide Toxaphene.

- Louisiana.--Lake Providence (Quanchita Basin) and Round Lake have deteriorated because of high levels of sediment and pesticide residues from agriculture. The state has banned private and commercial fishing in Lake Providence because of the high Toxaphene levels.

- New Mexico.--The state sees problems in the present and future use of the San Juan and Rio Grande Rivers for irrigation because of sediment and salinity.

- Oklahoma.--The Little Washita watershed has major water quality problems from sediment. Twelve other segments (out of 59) have major nonpoint source pollution problems.

- Texas.--Thirty-three out of 297 segments have existing or potential water quality problems related to nonpoint source pollution.

- Missouri.--Sediment and agricultural chemicals cause turbidity and violations of standards in the northern 38 percent of the state in the Salt, Fox, Wyaconda, and Upper Middle Fabius Rivers. In the Salt River,

21 percent of the basin has erosion rates of more than 30 tons per acre per year.

- Nebraska.--Eastern and central parts of the state have nonpoint source pollution problems stemming from small feedlots and the use of agricultural chemicals. The levels of nitrates, turbidity, fecal coliform bacteria, and total dissolved solids violate standards. Over 1.5 million acres have been identified as sources.

- Kansas.--Six areas have nutrient and salt problems from agricultural chemicals and irrigation return flows (Strager Creek, the Upper Nemaba River, the Upper Wakarusa River, the Wolf River, Washington State Lake, and Soldier Creek). These areas cover 627,000 acres and it would cost $70 million to treat them.

- North Dakota.--In the Souris River, agriculture has caused violations of the standards for nutrients, total dissolved solids, and suspended solids. These violations occur 80 percent of the time, and nonpoint source pollution accounts for 90 percent of the load. Nonpoint source pollution has killed many ducks. The state has identified 10,000 acres as having a high priority for treatment.

- South Dakota.--Agricultural nonpoint source pollution in the James River has affected fisheries and drinking water. The levels of suspended solids, total dissolved solids, and nutrients violate standards. The state has identified 17,000 acres that need treatment. Lake Herman suffers from excessive levels of sediment and nutrients. Its waters violate standards 100 percent of the time, and 90 percent of the load comes from nonpoint source pollution.

- Wyoming.--The Green River is affected by irrigation returns, overgrazing, and septic tanks. This situation threatens agriculture, recreation, and drinking water. Each year, public lands contribute 8.9 million tons of sediment and 145,000 tons of salt to the Green River. About 78 percent of the phosphorus loadings are from nonpoint sources, and this phosphorus causes eutrophication in the Flaming Gorge Reservoir. The Wind/Big Horn River is similarly affected. Nonpoint sources contribute 99 percent of the total phosphorus load in the Yellowtail Reservoir. Sources of phosphorus are fertilizer, septic tanks, feedlots, and eroded soil. Wyoming predicts that 11 of the 20 stream segments with problems will fail to meet water quality standards in 1983 because of nonpoint source pollution.

- Colorado and Utah.--The Colorado River is affected by agricultural runoff and hydrologic modification. Salt levels violate water quality standards. About 42 percent of the salinity in the upper basin is caused by irrigation that contributes 3,460 tons of salt to the river each year.

- Montana.--About 4,000 miles of the Missouri, Yellowstone, and Big Horn Rivers are degraded by nonpoint source pollution. Sediment affects 2,500 miles of these rivers, and salinity, 1,400 miles. The standards for salinity, bacteria, nutrients, and suspended solids have been violated.

- Idaho.--There are severe water quality problems in 5 stream reaches in irrigated areas involving 350,000 acres and in 18 reaches in nonirrigated areas involving 1.3 million acres. Less severe problems occur in 45 reaches involving 5 million acres. In these cases, fisheries and recreation are harmed by turbidity, sediment, algae, reduced oxygen, bacteria, salinity, temperature problems, and reduced flows.

- Washington.--The state identified priority water quality problems in 27 stream segments involving 1,700 dairies, 1 million irrigated acres, and 5.2 million nonirrigated acres. Turbidity, sediment, algae, reduced oxygen, temperature problems, bacteria, salinity, and reduced flows are damaging fisheries and recreation.

<u>Control Programs for Rural Nonpoint Source Pollution</u>.--As point sources are being brought under control, there is increasing awareness of the effects of nonpoint pollution sources on water quality. Over the past 4 years, EPA has increasingly emphasized the control of nonpoint source pollution. Through memoranda of understanding, EPA has asked for USDA's help in developing a nonpoint source control program for agriculture. EPA has added resources, particularly assessment and modeling to project future conditions, to its research on nonpoint source pollution. An extensive demonstration project is now underway in Iowa to validate procedures to monitor and evaluate best management practices (BMP's) (see glossary) for controlling agricultural pollutants. In fiscal year 1980, the budget for section 208 (see glossary) will be directed entirely to nonpoint source pollution problems, and more than half of the funds will be allocated to agricultural or related planning.

The USDA programs to control agricultural nonpoint source pollution are not precisely defined and are dispersed throughout the Department. Several agencies have defined water quality functions. These agencies are the Agricultural Stabilization and Conservation Service (ASCS); the Economics, Statistics, and Cooperatives Service (ESCS); the Farmers Home Administration (FmHA); the Forest Service (FS); the Science and Education Administration (SEA); and the Soil Conservation Service (SCS). The USDA Water Quality Work Group coordinates these programs.

During fiscal year 1978, USDA, acting with EPA, initiated the Model Implementation Program (MIP) in seven areas. ASCS allotted $1.5 million for cost-sharing assistance to landowners in the project areas. SCS provided accelerated technical assistance amounting to 40 work-years and $1.2 million in 1978. FS provided $77,000 to participating state forestry agencies.

During fiscal year 1979, USDA authorized 21 special water quality projects. Cost-sharing funds come from the $190 million in Agricultural Conservation Program (ACP) appropriations. ASCS transfers 5 percent of its ACP funds directly to SCS for technical assistance to landowners. SCS supplements this money with its own Conservation Operations funds. ASCS has also allotted $4.3 million for cost sharing from a $10 million national special projects fund reserve. In addition, a $10 million state reserve fund was established. Approximately $6.4 million of that reserve was devoted to projects that have water quality benefits. Water quality projects receive about 6 percent of all USDA funds appropriated for cost sharing with landowners. This represents about 2.5 percent of the annual investment needed to implement the

alternative recommended in the Environmental Impact Statement for the Rural Clean Water Program (USDA, 1978).

Title IV of Public Law 95-87 establishes an Abandoned Mine Reclamation Fund and four reclamation programs for federal, state, Indian, and rural lands. The Secretary of the Interior is responsible for all of these programs except the rural program. USDA, through SCS, is responsible for the Rural Abandoned Mine Program. The Secretary of the Interior may transfer up to 20 percent of the funds appropriated by Congress for the Abandoned Mine Reclamation Fund to SCS to carry out the program. For fiscal year 1978, this amount was about $11 million.

In addition to specific water quality projects, USDA provides technical, financial, and research assistance and information and education to landowners.

In 1977, Congress authorized USDA, with the concurrence of the Administrator of EPA, to carry out a Rural Clean Water Program (Public Law 95-217). In fiscal year 1978, Congress appropriated $2.4 million to SCS to develop rules, regulations, and policies for carrying out the program and to provide training to federal, state, and local units of government that would be involved in administering it. Formal rules were published November 1, 1978.

Cooperative efforts by USDA and EPA are concentrating on agricultural areas with critical water quality problems. The Model Implementation Projects and the Agricultural Conservation Program projects serve as prototypes that will lead to more extensive programs designed to combat agricultural nonpoint source pollution. These projects have also provided better understanding of cause and effect relationships, which should help USDA's effectiveness in controlling nonpoint source pollution. The ACP state reserve has allocated $6.4 million for 279 projects (table 3B-10).

Following are examples of water quality benefits anticipated from these projects.

- Arkansas.--At present, 47 of 60 streams in a priority watershed are not suitable for swimming and 37 of 60 are not suitable for fishing because of agricultural nonpoint source pollution. Installation of best management practices (BMP's) would reduce sedimentation by 75 percent.

- Idaho.--Two irrigated and two nonirrigated areas with severe nonpoint source pollution are developing individual farm water quality management plans to apply BMP's. BMP's for irrigated lands should reduce sediment by 60 to 80 percent; uncontrolled sedimentation was as high as 35 tons per acre per year. The annual cost of BMP's for all areas with the most severe agricultural nonpoint source pollution is about $11.5 million; the cost for second priority areas is about $26 million.

- Maine.--The Aroostook County ACP project covers 20,000 acres and 630 farms. Public water supply is involved. The BMP's to be applied should reduce soil loss to 10 tons per acre per year from present levels of more than 20 to 50 tons per acre per year. They should also reduce pesticide residues in local waters by 30 percent.

Table 3B-10.--Special water quality projects funded from state and county reserves

State	Number of special water quality projects approved from state reserves	State allocation to these projects	County allocation to these projects
	(Number)	(Dollars)	
Alabama	4	159,000	0
Alaska	0	0	0
Arizona	0	0	0
Arkansas	1	55,000	0
California	0	0	0
Colorado	2	198,599	0
Connecticut	2	21,000	10,000
Delaware	0	0	0
Florida	9	112,650	36,350
Georgia	7	276,000	262,200
Hawaii	0	0	0
Idaho	2	75,965	0
Illinois	9	349,560	11,000
Indiana	20	236,000	66,100
Iowa	3	95,633	16,000
Kansas	3	205,000	0
Kentucky	2	11,500	0
Louisiana	11	185,915	0
Maine	2	91,500	54,600
Maryland	2	57,000	0
Massachusetts	2	6,000	5,000
Michigan	10	288,000	28,104
Minnesota	7	254,000	0
Mississippi	10	318,044	0
Missouri	6	412,000	0
Montana	11	192,466	100,182
Nebraska	4	228,167	0
Nevada	4	56,500	15,942
New Hampshire	2	12,600	0
New Jersey	1	31,000	10,000
New Mexico	0	0	0
New York	9	148,000	122,500
North Carolina	9	321,500	85,000
North Dakota	4	150,000	0
Ohio	27	237,000	0
Oklahoma	4	165,700	0
Oregon	3	187,000	50,000
Pennsylvania	8	143,000	0
Puerto Rico	0	0	0

Table 3B-10.--Special water quality projects funded from state and county--Continued

State	Number of special water quality projects approved from state reserves	State allocation to these projects	County allocation to these projects
	(Number)	(Dollars)	
Rhode Island----------------	0	0	0
South Carolina--------------	1	53,000	0
South Dakota----------------	1	75,000	0
Tennessee-------------------	20	223,500	53,500
Texas-----------------------	2	60,000	0
Utah------------------------	12	92,150	131,905
Vermont---------------------	0	0	0
Virginia--------------------	6	171,000	171,000
Virgin Islands--------------	0	0	0
Washington------------------	1	70,000	30,000
West Virginia---------------	7	87,000	6,722
Wisconsin-------------------	29	335,691	0
Wyoming---------------------	0	0	0
Total-----------------	279	6,398,441	1,317,105

- North Carolina.--A program demonstrating BMP's has been conducted on a farm in Union County since September 1979. SCS has developed a management plan for all active farms. This plan could reduce soil loss to 4 tons per acre per year. The state has regulations which permit the issuance of special orders to control nonpoint sources of nitrogen.

- South Dakota.--The Model Implementation Project in the Lake Herman area has completed about 75 percent of the land treatment and designs for sediment control structures in the watershed. Interest in this demonstration has been extremely high, and other lake associations are attempting to form organizations to solve eutrophication problems.

Most agricultural BMP's are now selected from traditional soil and water conservation practices. Although we generally know how effective these practices are in reducing soil erosion, we are less certain of how effective they are in reducing the amount of sediment delivered to water bodies. Knowing the effectiveness of a soil and water conservation practice in controlling erosion does not translate into knowing that practice's effectiveness as a BMP for water quality control. EPA is now studying how to more adequately define the effectiveness of BMP's used to maintain water quality (EPA, 1979b). To date, EPA has found:

1. In general, the cost of reducing soil erosion by a given percentage is greater than the cost of achieving the same reduction in sediment. Reducing soil erosion by 90 percent costs about 4 times as much as obtaining an equivalent reduction in sediment.

2. Cost curves for all farms follow a common pattern. Cost-effectiveness is high at low levels of reduction in sediment. At a point between 70 percent and 90 percent, however, the cost effectiveness begins to decline sharply. Therefore, it is more cost effective to achieve moderate reductions in sediment loss over several farms than to attempt to achieve large reductions on only a few farms, assuming that all farms have roughly equivalent sediment loss.

3. Soil and water conservation practices significantly reduce the pollution in runoff from the ends of fields. They are better at reducing the amount of solid-phase pollutants in runoff (sediment, strongly adsorbed pesticides, organic nitrogen, and fixed phosphorus) than at reducing the amount of dissolved nutrients and pesticides. The amount of reduction depends on the site, local weather, soils, and crop management.

4. Soil and water conservation practices will not reduce the total "edge-of-field" nitrate losses (runoff plus percolation) unless they also reduce the application of fertilizer nitrogen.

5. Cropland erosion control measures may not efficiently reduce sedimentation in streams unless the measures are concentrated on lands with high losses of sediment.

6. Soil and water conservation practices often cost farmers money or have only marginal short-term monetary benefits. Conservation tillage and

no-tillage, however, can increase farm income in many cases. (Conservation tillage is reduced tillage that leaves plant residue on the soil surface.)

7. Efficiently managing chemical applications on croplands can significantly reduce pesticide and nitrogen losses. Although farmers do not always find such management operationally or economically acceptable, it does provide a major alternative to the use of soil and water conservation practices for pollution control.

8. Practices to control agricultural nonpoint source pollution must address specific problems. Tradeoffs are often involved. Practices employed to reduce one potential pollutant may increase others. For example, where sediment from cultivated croplands is a major problem, the use of no-till planting in crop residue is often specified. The use of this practice will often reduce cropland erosion and associated sediment, but it is likely to increase loadings of phosphorus from surface-applied fertilizers and decaying plant residue. This practice also requires more pesticides, which can move to receiving waters.

9. Soil and water conservation practices can influence water quality by reducing soil erosion or by reducing the sediment delivery ratio (see glossary). Most nonstructural practices (for example, conservation tillage, contouring, cover crops, and stripcropping) are primarily effective only in reducing soil erosion. Structural practices (terraces, diversions, grassed waterways) generally affect both soil erosion and the sediment delivery ratio.

10. The cost effectiveness of practices varies from farm to farm, depending upon many management factors. Four practices that are usually very cost effective are conservation tillage, no-till farming, contouring, and stripcropping.

11. Conservation tillage appears to have potential for widespread adoption by farmers.

12. The primary differences between farm plans for reducing sediment and those for reducing erosion were in the choice of fields where farmers implemented practices and in the location of practices within fields.

13. USDA programs that have emphasized soil erosion control may have to be adjusted to be cost effective in improving water quality. For example, a single terrace near the base of a slope may be very cost effective in reducing sedimentation but have little effect on soil erosion. A terrace of this type would not meet the requirements of existing USDA programs.

Tables 3B-11 through 3B-14 summarize and show the effectiveness of practices to control cropland erosion, direct runoff, and nutrient and pesticide losses.

Table 3B-11.--Practices for controlling erosion on cropland

Number	Erosion control practice	Practice highlights
E1	No-till planting in the residue of the previous crop.	Most effective in dominant grass or small grain; highly effective in crop residues; minimizes spring sediment surges and provides year-round erosion control; reduces labor, machine, and fuel requirements; delays soil warming and drying; requires more pesticides and nitrogen; limits fertilizer and pesticide placement options; some climatic and soil restrictions.
E2	Conservation tillage-------	Includes a variety of nonplow systems that retain some of the residues on the surface; more widely adaptable but somewhat less effective than E1; advantages and disadvantages are generally the same as E1 but to lesser degree.
E3	Sod-based rotations--------	Good meadows lose virtually no soil; reduces erosion from succeeding crops; total soil loss greatly reduced but losses unequally distributed over rotation cycle; helps control some diseases and pests; more fertilizer placement options; less realized income from hay years; greater potential transport of water soluble phosphorus; some climatic restrictions.
E4	Meadowless rotations------	Helps control diseases and pests; may provide more continuous soil protection than one-crop systems; much less effective than E3.
E5	Winter cover crops--------	Reduces winter erosion where corn residue has been removed and after low-residue crops; provides good base for slot-planting next crop; usually no advantage over heavy cover of chopped stalks or straw; may reduce leaching of nitrates; water use by winter cover may reduce yield of cash crop.
E6	Improved soil fertility----	Can substantially reduce erosion hazards as well as increase crop yields.

Table 3B-11.--Practices for controlling erosion on cropland--Continued

Number	Erosion control practice	Practice highlights
E7	Timing of field operations-	Fall plowing facilitates more timely planting in wet springs, but it greatly increases winter and early spring erosion hazards; optimal timing of spring operations can reduce erosion and increase yields.
E8	Plow-plant systems---------	A rough, cloddy surface increases infiltration and reduces erosion; much less effective than E1 and E2 during long periods of rain; seedling stands may be poor when moisture conditions are less than optimum. Mulch effect is lost by plowing.
E9	Contouring-----------------	Can reduce average soil loss by 50 percent on moderate slopes, but less on steep slopes; loses effectiveness if rows break over; must be supported by terraces on long slopes; soil, climate, and topographic limitations; not compatible with use of large farming equipment on many terrains. Does not affect application rates for fertilizers and pesticides.
E10	Graded rows----------------	Similar to contouring but less susceptible to row breakovers.
E11	Contour stripcropping------	A row crop and hay in alternate 50- to 100-foot strips reduce soil loss to about 50 percent of that with the same crops in rotation contoured only; fall seeded grain in lieu of meadow is about half as effective; alternating corn and spring grain is not effective; area must be suitable for across-slope farming and the establishment of rotation meadows; favorable and unfavorable features similar to E3 and E9.
E12	Terraces-------------------	Supports contouring and agronomic practices by reducing effective slope length and runoff concentration; reduces erosion and conserves soil moisture; facilitates more intensive cropping; conventional gradient terraces are often incompatible with use of large equipment, but new designs have solved this problem; substantial initial cost and some maintenance costs.

Table 3B-11.--Practices for controlling erosion on cropland--continued

Number	Erosion control practice	Practice highlights
E13	Grassed outlets------------	Facilitates drainage of graded rows and terrace channels with minimal erosion; involves establishment and maintenance costs and may interfere with use of large implements.
E14	Ridge planting-------------	Earlier warming and drying of row zone; reduces erosion by concentrating runoff flow in mulch-covered furrows; most effective when rows are across slope.
E15	Contour listing------------	Minimizes row breakover; can reduce annual soil loss by 50 percent; loses effectiveness with post-emergence corn cultivation; disadvantages same as E9.
E16	Change in land use---------	Sometimes the only solution. Well managed permanent grass or woodland is effective where other control practices are inadequate; lost acreage can be compensated for by more intensive use of less erodible land.
E17	Other practices------------	Contour furrows, diversions, subsurface drainage, land forming, closer row spacing, etc.

Table 3B-12.--Practices for controlling direct runoff[1/]

Number	Runoff control practice	Practice highlights
R1	No-till planting in prior crop residues.	Variable effect on direct runoff from substantial reductions to increases on soils subject to compaction.
R2	Conservation tillage----------------------	Slight to substantial runoff reduction.
R3	Sod-based rotations-----------------------	Substantial runoff reduction in sod year; slight to moderate reduction in row crop year.
R4	Meadowless rotations----------------------	Runoff reduction is none to slight.
R5	Winter cover crop-------------------------	Varies from increase to moderate reduction.
R6	Improved soil fertility-------------------	Slight to substantial runoff reduction depending on existing fertility level.
R7	Timing of field operations----------------	Slight runoff reduction.
R8	Plow-plant systems------------------------	Moderate runoff reduction.
R9	Contouring--------------------------------	Slight to moderate runoff reduction.
R10	Graded rows-------------------------------	Slight to moderate runoff reduction.
R11	Contour stripcropping---------------------	Moderate to substantial runoff reduction.
R12	Terraces----------------------------------	Varies from slight increase in runoff to substantial runoff reduction.
R13	Grassed outlets---------------------------	Slight runoff reduction.
R14	Ridge planting----------------------------	Slight to substantial runoff reduction.

Table 3B-12.--Practices for controlling direct runoff--Continued

Number	Runoff control practice	Practice highlights
R15	Contour listing	Moderate to substantial runoff reduction.
R16	Change in land use	Moderate to substantial runoff reduction.
R17	Other practices:	
	Contour furrows	Moderate to substantial reduction in runoff.
	Diversions	No runoff reduction.
	Drainage	Varies from an increase in runoff to a substantial decrease in surface runoff.
	Landforming	Varies from an increase in runoff to slight runoff reduction.
R18	Construction of ponds	Runoff reduction varies from none to substantial. Relatively expensive. Good pond sites must be available. May be considered as a treatment device.

1/ Erosion control practices with the same number are identical. The limitations and interactions shown in table 3B-11 also apply to runoff control practices.

Table 3B-13.--Practices for controlling nutrient loss from agricutural applications

Number	Nutrient control practice	Practice highlights
N1	Eliminating excessive fertilization--	May cut nitrate leaching appreciably; reduces fertilizer costs; has no effect on yield.
	Leaching Control	
N2	Timing nitrogen application----------	Reduces nitrate leaching; increases efficiency of nitrogen use; ideal timing may be less convenient.
N3	Using crop rotations-----------------	Substantially reduces nutrient inputs; not compatible with many farm enterprises; reduces erosion and pesticide use.
N4	Using animal wastes for fertilizer---	Economic gain for some farm enterprises; slow release of nutrients; spreading problems.
N5	Plowing under green legume crops-----	Reduces use of nitrogen fertilizer; not always feasible.
N6	Using winter cover crops-------------	Uses nitrate and reduces percolation; not applicable in some regions; reduces winter erosion.
N7	Controlling fertilizer release or transformation.	May decrease nitrate leaching; usually not economically feasible; needs additional research and development.
	Control of Nutrients in Runoff	
N8	Incorporating surface applications---	Decreases nutrients in runoff; no yield effects; not always possible; adds costs in some cases.
N9	Controlling surface applications-----	Useful when incorporation is not feasible.
N10	Using legumes in haylands and pastures.	Replaces nitrogen fertilizer; limited applicability; difficult to manage.
	Control of Nutrient Loss through Erosion	
N11	Timing fertilizer plow-down-----------	Reduces erosion and nutrient loss; may be less convenient.

Table 3B-14.--Practices for controlling pesticide loss from agricultural applications

Number	Pesticide control practice	Practice highlights
	Broadly Applicable Practices	
P1	Using alternative pesticides	Applicable to all field crops; can lower aquatic residue level; can hinder development of target species resistance.
P2	Optimizing pesticide placement with respect to loss.	Applicable where effectiveness is maintained; may involve moderate cost.
P3	Using crop rotation	Universally applicable; can reduce pesticide loss significantly; some indirect cost if less profitable crop is planted.
P4	Using resistant crop varieties	Applicable to a number of crops; can sometimes eliminate need for insecticide and fungicide use; only slightly useful for weed control.
P5	Optimizing crop planting time	Applicable to many crops; can reduce need for pesticides; moderate cost could be involved.
P6	Optimizing pesticide formulation	Some commercially available alternatives; can reduce needed rates of pesticide application.
P7	Using mechanical control methods	Applicable to weed control; will reduce need for chemicals substantially; not economically favorable.
P8	Reducing excessive treatment	Applicable to insect control; refined predictive techniques required.
P9	Optimizing time of day for pesticide application.	Universally applicable; can reduce necessary rates of pesticide application.

Table 3B-14.--Practices for controlling pesticide loss from agricultural applications--Continued

Number	Pesticide control practice	Practice highlights
	Practices Having Limited Applicability	
P10	Optimizing date of pesticide application---	Applicable only when pest control is not adversely affected; little or no cost involved.
P11	Using integrated control programs----------	Effective pest control using a reduced amount of pesticide; program development difficult.
P12	Using biological control methods-----------	Very successful in a few cases; can reduce insecticide and herbicide use appreciably.
P13	Using lower pesticide application rates----	Can be used only where authorized; some monetary savings.
P14	Managing aerial applications---------------	Can reduce contamination of nontarget areas.
P15	Planting between rows in minimum tillage---	Applicable only to row crops in nonplow tillage; may reduce amounts of pesticides necessary.

Scope

In determining the scope of its programs for solving water quality problems, USDA investigated two alternatives. These alternatives are described below.

- o Holistic programs.--This alternative would direct USDA programs toward all water quality problems. The programs would be directed toward agricultural nonpoint source pollution, urban nonpoint source pollution, pollution from individual disposal systems, and point sources of pollution.

- o Programs directed primarily at agricultural pollution.--This alternative would limit USDA programs to agricultural (including silvicultural) point and nonpoint source control activities and control of pollution from individual disposal systems. Programs directed toward control of urban point sources and urban nonpoint sources would be delayed pending further analyses.

USDA recommends that the second alternative be selected. To do otherwise would be beyond the capacity of the 1980 effort, given the time constraints placed on it.

In recommending this alternative, USDA assumed that (1) ongoing Department activity toward controlling pollution from point sources, urban nonpoint sources, and individual disposal systems would continue at present levels; and (2) future RCA analyses would include areas excluded from the 1980 RCA reports.

Focus

USDA is considering three alternative focuses: (1) the Department could treat water quality control as an associated benefit of other programs, (2) it could adopt a broad focus, for programs, or (3) it could focus only on the most critical areas or specific pollutants.

1. Under the first alternative, USDA would recognize that its other programs benefit water quality as they conserve soil and water and protect fish and wildlife habitat. USDA could integrate water quality objectives into these programs. The nature of the improvements in water quality would depend on the focus of the other programs.

2 If USDA chose the "broad focus" alternative, it would treat all pollutants equally. As much weight would be given to control of sediment as to control of toxics, dissolved solids, or organic waste. USDA would recognize that water quality problems are pervasive and would try to treat them anywhere they exist.

3. If the program were narrowly focused, USDA would concentrate on the critical areas identified in Section 208 water quality management plans. It would focus on aggregated subareas (ASA's) where critical areas could be treated at the least cost per unit of improvement in water quality. USDA's program would give priority to critical areas that are producing, in order of significance: (1)

toxic pollutants, (2) organic wastes, (3) nutrients, (4) dissolved solids (salinity), and (5) sediment.

This approach recognizes that critical areas are not uniformly distributed across the country, that a high percentage of the land within a critical area must be treated before water quality improves, and that too much money would be needed to work on all sources simultaneously.

USDA recommends that its 1980 soil and water conservation program focus available resources on ASA's that have the most critical water quality problems. Accelerated assistance should be concentrated in high priority areas identified in an approved Section 208 water quality management plan or in other areas that USDA identifies as being critically affected by, in order, (1) toxics, (2) organic wastes, (3) nutrients, (4) dissolved solids, and (5) sediment. In recommending this alternative, USDA assumes that--

- USDA programs will consider the effects on the natural environment and additional beneficial uses of waters that result from improved water quality.

- USDA will give higher priority to controlling agricultural nonpoint source pollution that affects human health than to preventing economic losses or protecting the natural environment.

- In the absence of specific quantitative data, the 1980 RCA analysis will use surrogates. For example, the amount of pesticides applied to cropland is used as a surrogate for specific data in calculations of pesticide loading.

- USDA will also have some ongoing conservation programs that address water quality problems outside of critical areas.

- USDA will provide assistance in more limited amounts to treat critical areas outside of critical ASA's.

- Critical areas will be treated primarily by applying best management practices (BMP's). BMP's will include both management practices (proper timing and amounts of fertilizers and pesticides, irrigation water management, residue management, etc.) and structural practices (grassed waterways, filter strips, terraces, conveyance and application systems for irrigation water, sediment basins and traps, etc.). The practices will be tailored to the soils, cropping systems, and kinds of pollutants. USDA will promote the development of innovative BMP's.

- USDA will give priority to the least costly ways to treat critical areas. Management BMP's will be used as the first step in the solution and then supplemented where necessary by structural BMP's.

ESCS has developed a model to identify and rank critical ASA's on the basis of social and environmental factors coupled with the effects of pollutants on water quality. Resources for the Future (RFF) has devised a National Water Network Model CARD-USDA that estimates pollutant loadings based on land use projections from the Linear Programming Model developed by USDA and the Center for Agricultural and Rural Development (CARD). Other social and

environmental factors must be considered along with the RFF estimates to identify ASA's with severe pollution problems. Once these factors are known, information on priority areas can be used to alter inputs to the CARD-SCS Linear Programming Model to provide new projected conditions. These models are discussed in detail in chapter 7.

In selecting the most critical ASA's, USDA will use the following assumptions:

- The density of population is important in ranking ASA's. This assumption is unpopular with people in less densely populated areas and with those who place high priority on enhancing or protecting the natural environment or on maintaining or improving recreational areas.

- The number of miles of polluted streams per square mile in the ASA is also important. This assumption is unpopular with those who would treat areas with the highest erosion rates no matter how little water is affected by the resulting sediment and associated pollutants.

- Pollutants that directly affect human health are more significant than those that primarily cause economic losses or that affect fish and wildlife.

- Resources are limited and should be used in the most treatable areas where the most water can be improved with a given investment. This approach will be unpopular with those who would treat the worst problems first regardless of the costs.

- The combined significance of all agricultural nonpoint source pollutants must be considered. This approach is unpopular with those who would select a single pollutant and invest all available resources on the control of that pollutant at the expense of controlling others. USDA selected this approach because neat boundaries normally do not exist between the various pollutants.

USDA gave equal weight to the following factors:

1. Population per square mile in the ASA.

2. Polluted miles of streams per square mile in the ASA.

USDA also assigned the pollutants relative levels of importance and ranked the ASA's accordingly.

Pollutant	Level of importance
Toxic substances------	4.0
Organic wastes--------	3.0
Nutrients-------------	2.5
Dissolved solids------	2.0
Sediment--------------	1.0

USDA developed a composite index that combines information on pollutant loadings, treatment costs, intensity of chemical and fertilizer use, and pollution levels estimated by the CARD-SCS Linear Programming Model and the RFF Model. Standardized values are computed for the various factors and combined for each pollutant category. The values for the pollutant categories are weighted as outlined above to develop the composite index.

The priority model was designed to identify ASA's where the more critical pollutants or combination of pollutants are affecting a large number of people, where existing pollution problems are severe, and where a dollar spent will yield the largest return.

Alternative Objective Levels

USDA defined three alternative levels for water quality objectives. USDA could use any one of these alternatives in future programs, depending on the objective levels it chooses for the other potential problem areas.

USDA defines adequate treatment as the level of treatment necessary to meet the following water quality goals:

Pollutant	Goal
Sediment	0.2 ton/acre/year
Organic waste	200 coliforms/100 milliliters
Nitrogen	10 milligrams/liter
Phosphorus	0.3 milligram/liter
Dissolved solids	500 milligrams/liter
Toxics	zero

In terms of the proportion of areas adequately treated, these objective levels could be:

- High level objectives.--Adequately treat 75 percent of the critical areas in the 20 most critical ASA's, 50 percent in the next 20 most critical ASA's, and 20 percent in the remaining ASA's.

- Medium level objectives.--Adequately treat 50 percent of the critical areas in the 20 most critical ASA's, 25 percent in the next 20 most critical ASA's, and 10 percent in the remaining ASA's.

- Low level objectives.--Adequately treat 25 percent of the critical areas in the 20 most critical ASA's and 5 percent of the critical areas in the remaining ASA's.

Recommendations for Future Analysis

Identifying water quality problems is one part of the Section 208 planning carried out under the Clean Water Act. This planning effort covers the entire United States. Fifty statewide and 176 areawide plans are being developed, certified by governors, and approved by the Environmental Protection Agency. By October 1, 1979, 41 statewide plans and about 159 areawide plans were completed. Together, these plans will show the extent

and severity of water quality problems. Although time will not permit compiling these data for the 1980 RCA reports, the approved plans will provide a solid base for the 1985 reports. USDA should develop a systematic method for analyzing and using the Section 208 plans in the 1985 RCA analysis.

The 1980 RCA analysis was hampered by the lack of specific data on how applying best management practices to varying degrees affects water quality. Research in this area is expanding and should be strongly encouraged so that better data are available for the 1985 reports.

Socieconomic research should be conducted using the Model Implementation Plans and the Agricultural Conservation Program special water quality projects to determine what mix of incentives would best encourage landowners to apply best management plans.

In the short term, it is unrealistic to expect to have monitoring data on small critical watersheds in sufficient detail to document the extent of water quality problems or to determine the effects of control efforts. (Many efforts may be deferred for several years.) However, a number of predictive models have been or are being developed. The use of these models should be encouraged, and their reliability should be verified.

References

Council on Environmental Quality. 1978. Environmental quality: The ninth annual report. GPO No. 041-011-00040-8, 599 pp.

Environmental Protection Agency. 1977. National water quality inventory: 1976 report to Congress. Office of Water Planning and Standards. GPO No. 440-9-76-024.

Environmental Protection Agency. 1978. National water quality inventory: 1977 report to Congress. Office of Water Planning and Standards, 27 pp.

Environmental Protection Agency. 1979a. 1978 Needs survey: Cost estimates for construction of publicly owned wastewater treatment facilities. Office of Water Program Operations, GPO No. 430-9-79-001.

Environmental Protection Agency. 1979b. Analysis for oversight hearings and testimony for the Record; Hearings before the subcommittee on Oversight and Review, House of Representatives, Committee on Public Works and Transportation. July 18, 1979. (Unpublished)

General Accounting Office. 1977. National water quality goals cannot be attained without more attention to pollution from diffuse or nonpoint sources. Report to Congress, CED-78-6, December 20, 1977.

House of Representatives. 1976. Hearings on water quality research. Subcommittee on Science and Technology, Sept. 28-Oct. 1, 1976. GPO No. 106.

National Commission on Water Quality. 1976. Staff report. April 30, 1976.

Spaulding, Willard M., Jr., and Ronald D. Ogden. 1968. Effects of surface mining on the fish and wildlife resources of the United States. USDI, Bureau of Sport Fisheries and Wildlife. Resource Publ. 68. 51 pp.

United States Department of Agriculture, Soil Conservation Service. 1978. Environmental impact statement: Rural clean water program. 158 pp.

United States Water Resources Council. 1978. The Nation's water resources, 1975-2000. Second Natl. Water Assess.

Wadleigh, Cecil H. 1968. Wastes in relation to agriculture and forestry. U.S. Dep. Agric. Misc. Publ. No. 1065, 112 pp.

Section C-Potential Problem Area 3, Water Supply and Conservation

Problem Statement

Although the United States has an ample supply of water from both surface and underground sources, the uneven distribution of precipitation often causes regional or local shortages. Although generally associated with the arid West, water shortages can occur in any season and in any part of the Nation. Many humid areas of the East experience periodic water shortages. At times, inadequate water supplies can be caused by poor water quality or by economic, social, or environmental constraints (USWRC, 1978).

The dependability of surface water supplies is as important as their location. Water plans must consider probable yearly and seasonal variations. Reservoirs may be needed to store water during periods of excess for release as needed.

During the past 25 years, the use of ground water has increased faster than the use of surface water. Although they are interrelated, we know less about ground water than we do about surface water. The overdraft of ground water is a serious concern. About 25 percent of all ground water currently withdrawn is overdraft.

All offstream users of water compete for the available supply. As competition becomes more intense, conflicts will occur. Consumptive uses other than irrigation may double by 2000, from 20.2 billion gallons per day (bgd) to 42.6 bgd (USWRC, 1978). The emphasis on energy production may develop additional uses. Irrigation use is expected to increase by 6.1 bgd, from 86.4 bgd to 92.5 bgd, although some state and regional planners suggest that the increase may be double that figure (to 100 bgd).

Irrigation is the major consumer of water. Water used for livestock and rural communities, while important, is but a small fraction of that used for irrigation. The most widespread need for the remaining available water is instream use. The estimated instream flow requirements for fish and wildlife are the highest of all instream uses.

Recent recognition of and increased public commitment to instream fish and wildlife water needs could involve more of the Nation's water supply than all other uses combined. This would cause intense competition between instream and offstream uses. Disagreement on how much water is needed for each use will make it difficult to find an appropriate balance. Although reliable estimates of instream requirements are sometimes available, finding an equitable means for allocating water to this use is a major problem.

The Problem in Detail

Types of water shortages.--Water shortages exist wherever demands exceed supplies. In chronic water-short areas, rechargeable ground water and surface water supplies are inadequate to meet withdrawal demands in years of average precipitation. In these areas, demands can be met only by depleting (mining) ground water (see "ground water mining" in the glossary). Soil moisture and ground and surface water supplies are not replenished during

droughts. Flood waters are lost for possible beneficial use. Poor water management increases water pollution from nonpoint sources.

o Insufficient Soil Moisture for Crop Production.--"Rainfed" and dryland agriculture, involving 356 million acres, produces 75 percent of the food and fiber in the United States. Most of the food products exported to meet world food needs are produced on nonirrigated lands.

Soil moisture plays a key role in the food chain of plants. Agricultural activity must be adapted to the moisture conditions of the climatic regions. In the humid regions, agriculture depends on precipitation with some supplemental irrigation for high value crops. In the semihumid and semiarid regions, farming depends primarily on stored soil moisture and increasingly on irrigation. In the arid regions, crop production depends totally on irrigation.

In humid areas, primarily east of the 98th meridian or on western slopes near the Pacific Ocean, the safe removal of excess water from the land is a concern. The root-zone profile is generally filled between the harvest of one crop and planting of the next crop. Precipitation during the growing season is generally adequate to ensure reasonable crop production, and water erosion is sometimes a hazard. Nevertheless, moisture deficiencies during the growing season are common, especially on sandy soils. This affects the quantity and quality of crop production. Unless conservation measures are applied, even short dry periods can reduce yields on half of the 150 million acres of humid cropland.

The type of crop and the soil influence soil moisture. Drying of soil where plants are growing depends on the plant rooting depth, the amount of water in the soil, and the ability of the soil to give up that water to plants. Improving soil moisture availability could increase yields an average of about 5 percent.

Water conservation is a major concern on cropland and rangeland where water availability is the primary factor limiting crop and forage production. In some areas, soil moisture is so low that the land must be left idle for an entire growing season in order to accumulate sufficient soil moisture for crop production. In most subhumid and semiarid areas, precipitation is normally adequate to support dryland crops and rangeland forage 4 years out of 5 (USDA, 1979).

There are more than 850 million acres of public and private rangeland in the United States. This includes nearly 400 million acres of federal rangeland, administered by the Department of the Interior, and about 45 million acres of nonfederal rangeland. In addition, there are over 61 million acres of nonfederal grazed forest land and 58 million acres of grazed forest land administered by USDA. All of this land provides the principal source of forage for thousands of cattle and sheep operations in the 17 western states. Production on most of this land is limited by precipitation; it is estimated that this range is producing at about 40 percent of its potential. The growing population and rising demand for beef will probably increase the demand for range grazing. But urbanization and irreversible land use changes will probably remove about 0.5 million acres of rangeland per year from grazing use.

o Irrigation Water Requirements.--More water is withdrawn for agriculture than for any other functional use. About 47 percent of the fresh water withdrawn is for irrigation. About 81 percent of consumption--water withdrawn from and not returned to ground or surface sources--is for irrigation (USWRC, 1978).

The amount of irrigated land has doubled in the past 30 years (table 3C-1) Recent increases have been especially large in Nebraska and western Kansas. Although irrigated acreage increased nationally, half of the counties reporting irrigated land in the 1974 Census of Agriculture had a net loss in irrigated land. This usually reflected temporary or permanent limitations on the water supplies (USDA, 1977a). Net acreage of irrigated land will need to increase to keep pace with increased food and fiber demands.

The development of irrigated farming has had considerable impact on the agricultural economy of the United States, particularly in the 17 western states. A recent study found that the average number of acres of irrigated cropland harvested in 1971-73 was about 12 percent of the total acreage of all cropland harvested, but irrigated production amounted to 27 percent of the total value of all U.S. cropland production, or about $12 billion (U.S. Dep. of Commerce, 1974).

The regional importance of irrigated crop production varies considerably. In the early 1970's, nearly 90 percent of the total value of crops produced in California; over 80 percent in Utah, Idaho, New Mexico, Oregon, Colorado, Texas, and Florida; and nearly 50 percent in Nebraska were produced on irrigated land. Nevada and Arizona have very little nonirrigated cropland.

The value of irrigation to the farmer is higher per acre for fruits and vegetables than for most field crops. Fruits and vegetables have high investment and production costs per acre. This increases the economic risk if the crop fails or yield is reduced because of drought. Irrigation reduces the risk of not getting adequate rainfall, allowing farmers to produce a plentiful supply of a high quality product at a lower cost.

Irrigation return flows and agricultural land runoff are dominant nonpoint pollution sources (see glossary). This problem is discussed in section 3B, Water Quality.

The total economic or social value of irrigation is more than just the increase in agricultural production. Additional economic growth is also generated in the agricultural processing and marketing industries. As production increases, the demand for fertilizer, machinery, pesticides, labor, and other commodities increases. This generates economic growth which is estimated to be approximately equal to the growth in the value of agricultural production.

o Water for Other Uses.--Water shortages and poor quality water supplies are severe problems for sustained production of livestock. Rural household users also have problems with insufficient water supplies and supplies that do not meet drinking standards. These problems are common for the 17 percent of the population that have their own water systems and for those who are served by small community central systems.

Table 3C-1.--Top 20 states in the number of acres irrigated (1974)

State		Irrigated acres (1,000's)			
		1944	1954	1964	1974
California	1--------------	4,952	7,048	7,599	7,749
Texas	2--------------	1,320	4,707	6,385	6,594
Nebraska	3--------------	632	1,171	2,169	3,967
Colorado	4--------------	2,699	2,263	2,690	2,874
Idaho	5--------------	2,026	2,325	2,802	2,859
Kansas	6--------------	96	332	1,004	2,010
Montana	7--------------	1,555	1,891	1,893	1,759
Oregon	8--------------	1,129	1,490	1,608	1,561
Florida	9--------------	222	428	1,217	1,559
Wyoming	10--------------	1,354	1,263	1,571	1,460
Washington	11--------------	520	778	1,150	1,309
Arizona	12--------------	726	1,177	1,125	1,153
Utah	13--------------	1,124	1,073	1,092	970
Arkansas	14--------------	289	858	974	949
New Mexico	15--------------	535	650	813	867
Nevada	16--------------	674	567	825	778
Louisiana	17--------------	536	708	581	702
Oklahoma	18--------------	2	108	302	515
Mississippi	19--------------	1/	132	123	162
South Dakota	20--------------	53	90	130	152
All other states-----------------		85	493	1,003	1,294
50 states, total-----------		20,539	29,552	37,056	41,243

1/ Less than 500 acres.
Source: U.S. Dep. of Commerce, 1974.

For domestic and commercial purposes, central water supply systems provided an average of 27 billion gallons per day (bgd) to 179 million people. About 21 bgd were treated and returned to water supplies. Domestic and commercial use is expected to increase 20 percent during the next 25 years.

Water consumption for manufacturing is expected to increase from 6 bgd to 15 bgd by 2000 even though recycling is expected to increase tenfold because of pollution control limitations on water discharge (USWRC, 1978). Water consumed for steam-powered generation of electricity will probably increase about seven times because of changes in cooling technology. The increased production of energy from other fuels, such as coal and oil shale, will require more water. Problems in water supplies for energy production are emerging in water-short areas where there are large coal and oil shale deposits.

Water supplies are already limited for cities, industry, mining, energy production use, irrigation, livestock, and rural domestic use. Study teams identified specific problems during the Second National Water Assessment (fig. 3C-1).

o Diminished Streamflow.--Diversions of water for offstream uses have significantly modified the natural environment. In some cases, these diversions and consumptive uses have resulted in depleted streamflow, ground water overdrafts, degradation of water quality, and modification of terrestrial and aquatic habitats. In other cases, the supply and distribution systems have extended seasonal streamflow, improved the quality of water and aquatic habitat, and provided flood control and recreational opportunities. Depleted streamflow in 22 percent of the subregions has seriously degraded instream flow conditions for fisheries, wildlife, and recreation. Depletions in another 18 percent of the subregions have caused instream flow conditions that are less desirable for aquatic life. During dry periods, every subregion has at least some months in which streamflows are less than the optimum for aquatic life.

Streamflow depletion can affect water quality as well as water quantity. Agricultural irrigation can degrade water quality through a concentrating process (increasing the concentration of substances in the water through transpiration and evaporation) and a loading process (adding contaminants from soils and substrata to the return flow).

Diverted water, particularly water used in agriculture, has created significant environmental impacts.

- Seepage from both conveyance and farm distribution systems has created diverse forms of fish and wildlife habitat ("induced wetlands"). This affects riparian ecosystems and the small game, waterfowl, and other residents of these systems.

- Seepage from irrigation conveyance systems and irrigation water application has increased the recharge of aquifers.

- Diversions of water from some streams have degraded the quality of aquatic communities and affected the migration of anadromous fish.

Subregion with inadequate streamflow ("1975"-2000)

- 70 percent depleted in average year
- 70 percent depleted in dry year, and average year
- Less than 70 percent depleted

Specific problems *(as identified by Federal and State/Regional study teams)*

★ Conflict between offstream and instream uses

Inadequate supply of fresh surface water to support—

Offstream use

● Central (municipal) and noncentral (rural) domestic use

□ Industry or energy resource development

▲ Crop irrigation

Instream use

■ Fish and wildlife habitat or outdoor recreation

♦ Hydroelectric generation or navigation

Figure 3C-1.--Problems of inadequate water supply. (USWRC, 1978)

- Return flows from irrigated areas may contain biocide residues, salts, nutrients, and sediment, and may reduce the quality of many facets of the environment.

Causes of Water Shortages.--Shortages of water are caused by scarce water supplies, water demands (requirements) larger than water yield, fluctuating water supplies, and fluctuating water demands. Water deficits may result from one or more of these causes.

o Scarce Water Supplies.--Water shortages occur when precipitation is not sufficient to replenish ground and surface supplies. Supply shortages are likely to be prevalent in areas that are underlain with aquifers yielding less than 50 gallons per minute to wells and that have less than 1 inch of runoff (fig. 3C-2). Generally, areas receiving less than 20 inches of precipitation (see Appraisal Part I, p. 5-3) have less than 1 inch of runoff.

o Requirements Larger than Water Yield.--Water shortages occur when the demand for water exceeds the available supply. About 340 billion gallons per day (bgd) of fresh water are withdrawn from the over 1,300 bgd steady-state yield in the conterminous United States. Nearly 230 bgd of the withdrawals are returned to the streams and aquifers. About 106 bgd are consumed, and 15 bgd are lost through evaporation. Nationally, depletions account for less than 10 percent of the steady-state yield. But in 8 of the 99 subregions in the conterminous United States, water depletions in the year 2000 are expected to exceed 90 percent of the average streamflows (fig. 3C-3). In some months, offstream uses require less than 1 percent of the average streamflow in the New England Region, whereas offstream uses require all the flow in most months in the Lower Colorado Region.

o Fluctuating Water Supplies.--The varied geographic and climatic conditions of the United States cause precipitation patterns to continuously change. Precipitation, and the resulting runoff and streamflow, varies widely from year to year. There is much more water flowing out of a water resources region in a very wet year than in a very dry year. (See Appraisal Part I, pp. 5-14 and 5-15.) Annual streamflow in 8 years out of 10 is less than 70 percent of the mean annual flow in 44 percent of the subregions.

Seasonal variations occur in runoff and streamflow. (See Appraisal Part I, pp. 5-17 to 5-19.) Monthly precipitation may vary by more than 400 percent. (See Appraisal Part I, p. 5-13.) In six months of a dry year, flows may be less than half of what they are in an average year in 40 percent of the subregions. Normal monthly distribution of runoff in figure 3C-4 illustrates the fluctuating supplies.

Droughts. Crops from most of the Nation's cropland and forage from nearly all of the grazed land are dependent upon rainfall. Although the 30 to 50 inches of precipitation per year in the humid areas is usually sufficient for crop production, droughts of several weeks to several months occur in most years. In subhumid and semiarid areas, the 10 to 30 inches of precipitation per year is normally adequate to support dryland crops and rangeland forage. Precipitation during the growing season significantly affects production in 2 years out of 10 (USDA, 1979).

Figure 3C-2.--Areas of scarce water supplies. Source: U.S. Water Resources Council. 1975. Livestock water use. Appendix C-1, Nationwide Analysis.

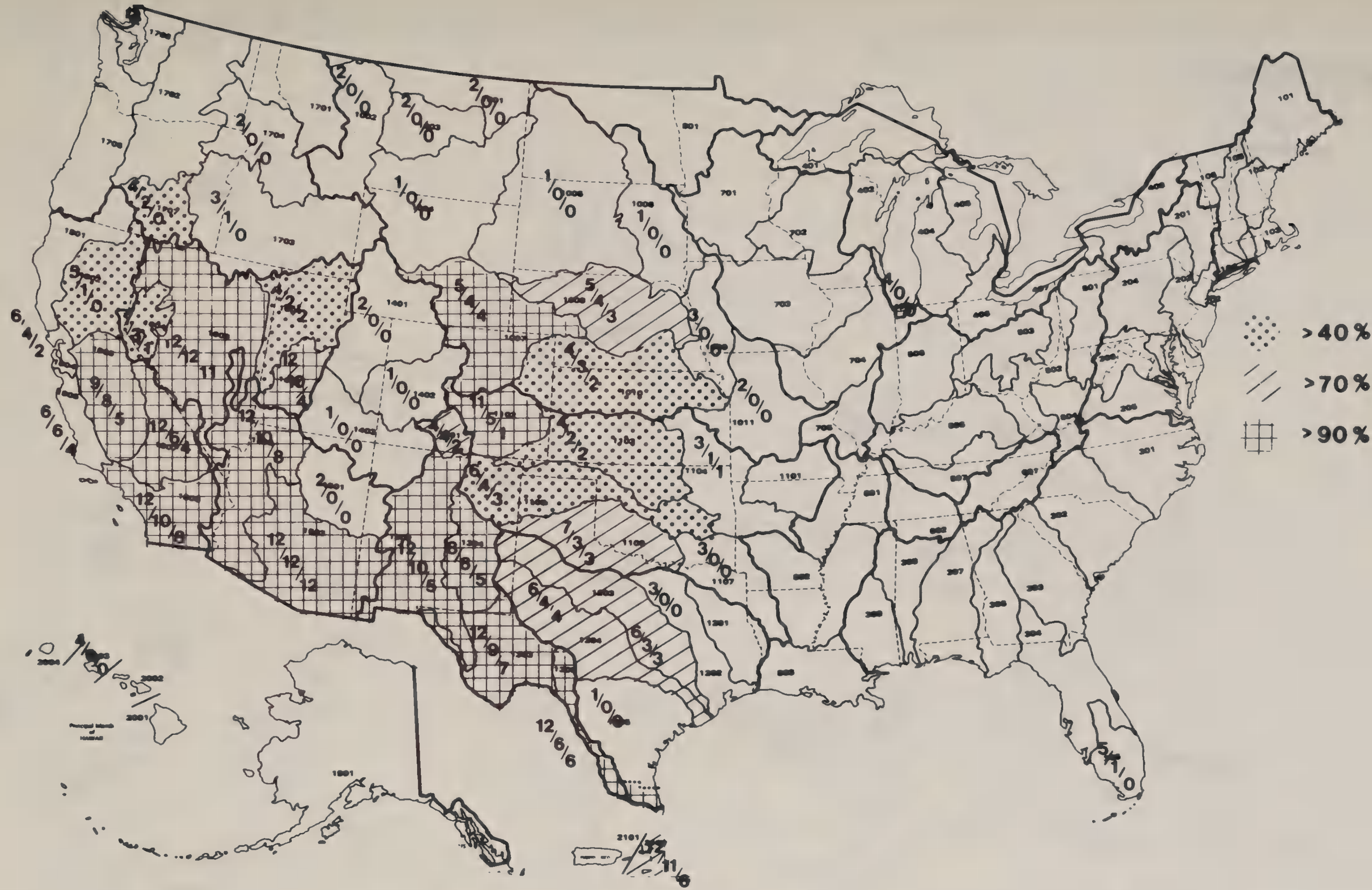


Figure 3C-3.--Expected streamflow depletion by the year 2000 and number of months in which streamflow depletion exceeds 40/70/90 percent, by subregion. (USDI et al., 1979)

Figure 3C-4.--Normal monthly distribution of runoff. Source: U.S. Department of the Interior, Geological Survey. 1970. The national atlas of the United States of America.

Periods of abnormally low moisture sometime persist beyond a single growing season. Long droughts are most common in arid and semiarid areas. These droughts exhaust the available soil moisture, empty reservoirs, and fail to replenish lakes and streams or recharge aquifers. See figure 3C-5, and also see Appraisal Part I, p. 5-22.

Floods. Streams and rivers do not have the capacity to carry abnormally large amounts of water. Water spills over the stream channel and inundates adjacent areas (flood plains). There are about 187 million acres of nonfederal flood prone land in the United States. Of this, 48 million acres are cropland; 106 million acres are pasture, range, and forest land; and 33 million acres are other land, including urban and built-up areas (USDA, 1978). Twenty-one thousand communities (6,150 having populations over 2,500) experience flooding. In 1975, the estimated potential property damage from floods was $3.4 billion (1975 dollars). Upstream flooding is discussed in section 3E, Upstream Flood Damages.

Most of the water that causes flood damage flows to the sea providing little beneficial use. Total flows into the ocean in the conterminous United States average 1,223 bgd. This includes over 230 bgd of water that was withdrawn from and returned to the system. Much of this flow is needed to satisfy instream requirements. In some years as much as 2000 bgd flows into the ocean. In flood years, some 200 trillion gallons of water may be lost to any beneficial use.

o Fluctuating Water Demands.--Water demands are the amounts of water of acceptable quality needed at a particular location for use during a stated period of time. Each water use has its own water requirement. Water demands fluctuate widely depending on the particular use and time.

In 1975, an estimated 8.2 bgd was withdrawn from ground-water supplies and 9.5 bgd was withdrawn from surface supplies for livestock, rural households, and small communities in the U.S. and Caribbean area. About 6.2 bgd were consumed, and the remaining 11.5 bgd were returned to the system. Livestock and domestic use varies markedly during the day. Domestic use is lowest during the night, then increases about six times to an 8:00 a.m. peak. Livestock operations peak use occurs during feeding and cleanup periods and when animals come in from the field.

Household water use ranges from 8 to 80 gallons per capita per day. It varies during the year because of lawn and plant watering, vehicle washing, and such personal uses as bathing. The design of noncentral water supply systems must recognize monthly variations. Livestock requirements vary because of composition of the herd or flock; temperatures; seasonal rations; and evaporation from stock water ponds.

In 1975, an estimated 56 bgd were withdrawn from ground water supplies and 102 bgd were withdrawn from surface supplies for irrigation in the U.S. and Caribbean area. About 86 bgd were consumed and the remaining 72 bgd were returned to the system. Irrigation water is usually applied only during the growing season. Irrigation water requirements vary because of climate, soil moisture, precipitation during the growing season, crop requirements, application efficiencies, and conveyance and delivery systems.

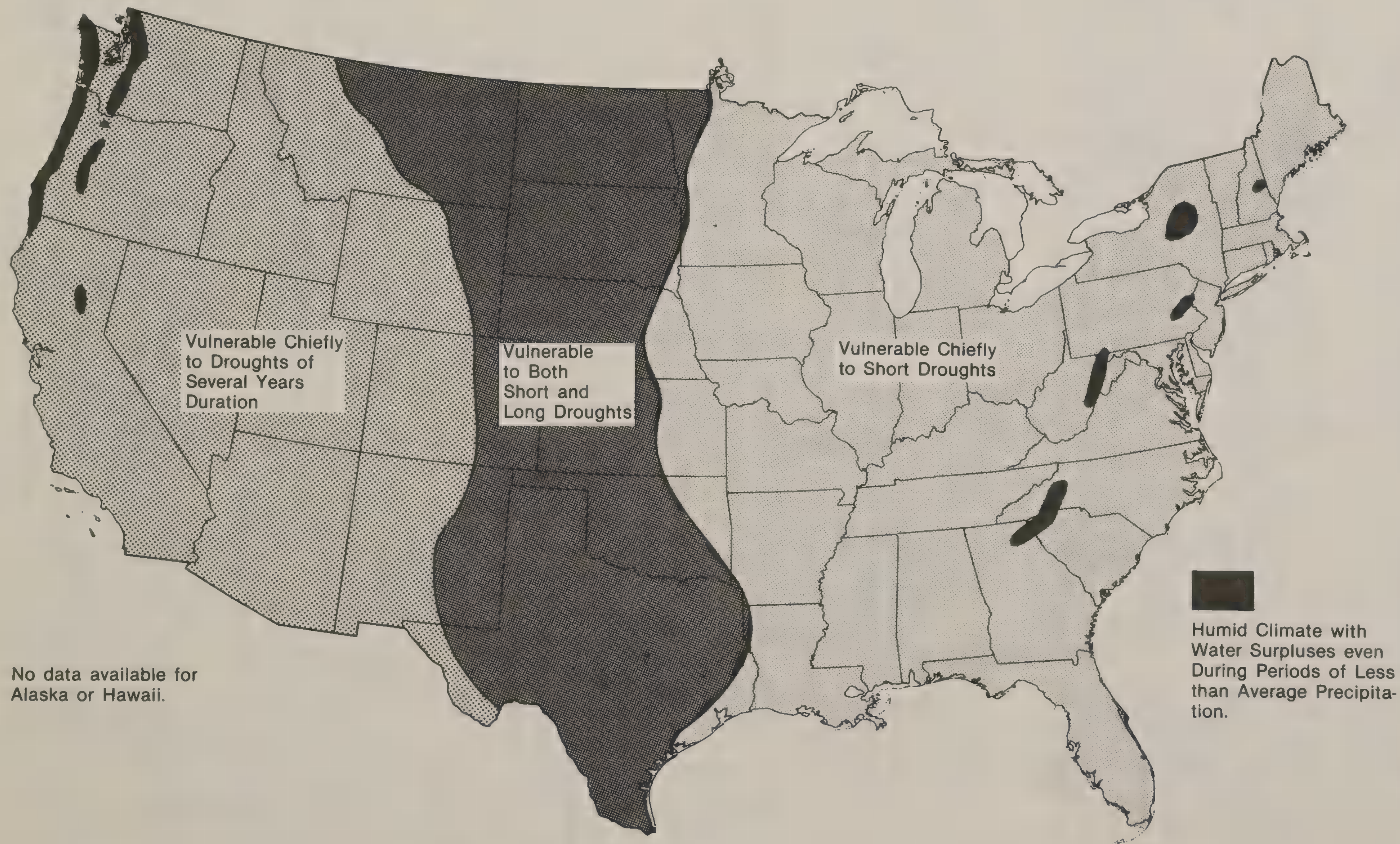


Figure 3C-5.--Areas vulnerable to drought. Source: U.S. Department of the Interior, Geological Survey. 1970. The national atlas of the United States of America.

Many water resource planners do not use the "bdg" measurement because they believe that averaging water quantities over the year gives a distorted impression.

Values of instream flows relate to uses made of water in the stream channel, including maintaining fish and wildlife, outdoor recreation, navigation, hydroelectric generation, waste assimilation, and ecosystem maintenance. Streamflow should be sufficient to sustain these uses. The amount of water flowing through a natural stream channel needed to sustain the instream values at an acceptable level varies considerably during the year.

Water Supply Problem Areas.--Water supply shortages exist in 60 percent of the Nation's hydrologic subregions (USWRC, 1978). Competition for scarce supplies is greatest in arid and semiarid areas. Regional average annual data often mask local periodic water shortages. The number of months that water requirements exceed supplies is shown in Appraisal Part I, pages 5-64. Nearly every part of the Nation experiences water shortages at times, but shortages are most prevalent in the arid and semiarid western states.

Nationwide, an estimated 81 percent of all water consumed is used in irrigation. In arid and semiarid areas, water consumed for irrigation may exceed 90 percent (table 3C-2). Streamflows are often inadequate to maintain instream values (fig. 3C-6).

o Water Short Areas.--Deficits most often occur in areas where depletions are large. USDA has identified areas of impending agricultural water supply shortages as areas in which a depletion of 40 percent or more of the surface water available is expected to occur during critical average months in 1985 (fig. 3C-7).

For figure 3C-8, hydrologic units are designated as water-short if:

(1) Streamflow depletion during a critical month (month when deficiency is greatest or surplus flow is least) is 40 percent or greater, or

(2) Streamflow depletion during any month is 70 percent or greater, or

(3) Streamflow is deficient two or more months, where the ratio of total annual use to total streamflow exceeds 60 percent.

Based upon projected water data for 1985 (USWRC, 1978), and applying the above criteria, there are a total of 56 water short aggregated subregions (ASR's) in 15 regions covering all or part of 30 states in the conterminous United States. Most of these areas are in subhumid, semiarid, and arid climates (see Appraisal Part I, p. 5-20) and have scarce water supplies (see fig. 3C-2). The 17 western states (fig. 3C-9) are considered the water-short areas for this report.

States with humid climates generally have sufficient water. Water shortages can occur, however, during dry periods or high withdrawal periods, especially at locations away from the source.

o Ground Water Overdraft Areas.--Over 25 billion acre-feet of ground water in the United States can be feasibly withdrawn. The potential steady-state

Table 3C-2.--Comparison of regional water availability and projected use
(billion gallons per day)

Water resources region	Annual streamflow: Mean streamflow	Annual streamflow: Once-in-5-year drought streamflow	Year 2000 total Offstream wate use: Withdrawal	Year 2000 total Offstream wate use: Consumption	Year 2000 irrigation 1/ Offstream water use: Withdrawal	Year 2000 irrigation 1/ Offstream water use: Consumption
1. New England---------	78.1	62.7	3.2	1.1	0.1	2/
2. Mid-Atlantic--------	79.1	61.2	13.9	3.5	0.5	0.4
3. South Atlantic-Gulf-	228.0	164.1	28.3	10.1	4.5	3.6
4. Great Lakes---------	72.7	57.3	25.6	4.7	0.3	0.2
5. Ohio----------------	178.0	141.0	16.9	4.3	0.1	0.1
6. Tennessee-----------	40.8	35.9	6.0	1.1	2/	2/
7. Upper Mississippi---	121.0	91.8	7.9	2.7	0.4	0.3
8. Lower Mississippi---	433.0	282.0	24.8	5.5	4.4	3.3
9. Souris-Red-Rainy----	6.0	3.4	0.6	0.4	0.4	0.3
10. Missouri------------	44.1	29.9	44.4	19.9	36.2	17.6
11. Arkansas-White-Red--	62.6	37.4	13.3	8.9	9.8	7.1
12. Texas-Gulf----------	28.3	12.3	15.5	10.5	7.4	6.1
13. Rio Grande----------	1.2	.3	5.6	4.0	4.9	3.6
14. Upper Colorado------	10.0	7.0	7.5	3.2	6.7	2.7
15. Lower Colorado------	1.6	1.4	7.9	4.7	6.3	3.7
16. Great Basin---------	10.6	5.7	7.3	4.0	5.8	3.2
17. Pacific Northwest---	225.3	213.3	33.8	15.2	30.0	13.2
18. California----------	48.2	30.4	41.3	29.7	34.8	26.3
19. Alaska--------------	905.0	795.0	0.8	0.5	2/	0.5
20. Hawaii--------------	6.7	4.9	1.4	0.7	1.0	0.5
21. Caribbean-----------	4.8	3.3	0.9	0.3	0.3	0.2

1/ Irrigation water use is for an average year; dry year requirements are larger.
2/ Negligible--less than 50 million gallons per day.

Source: USWRC, 1978.

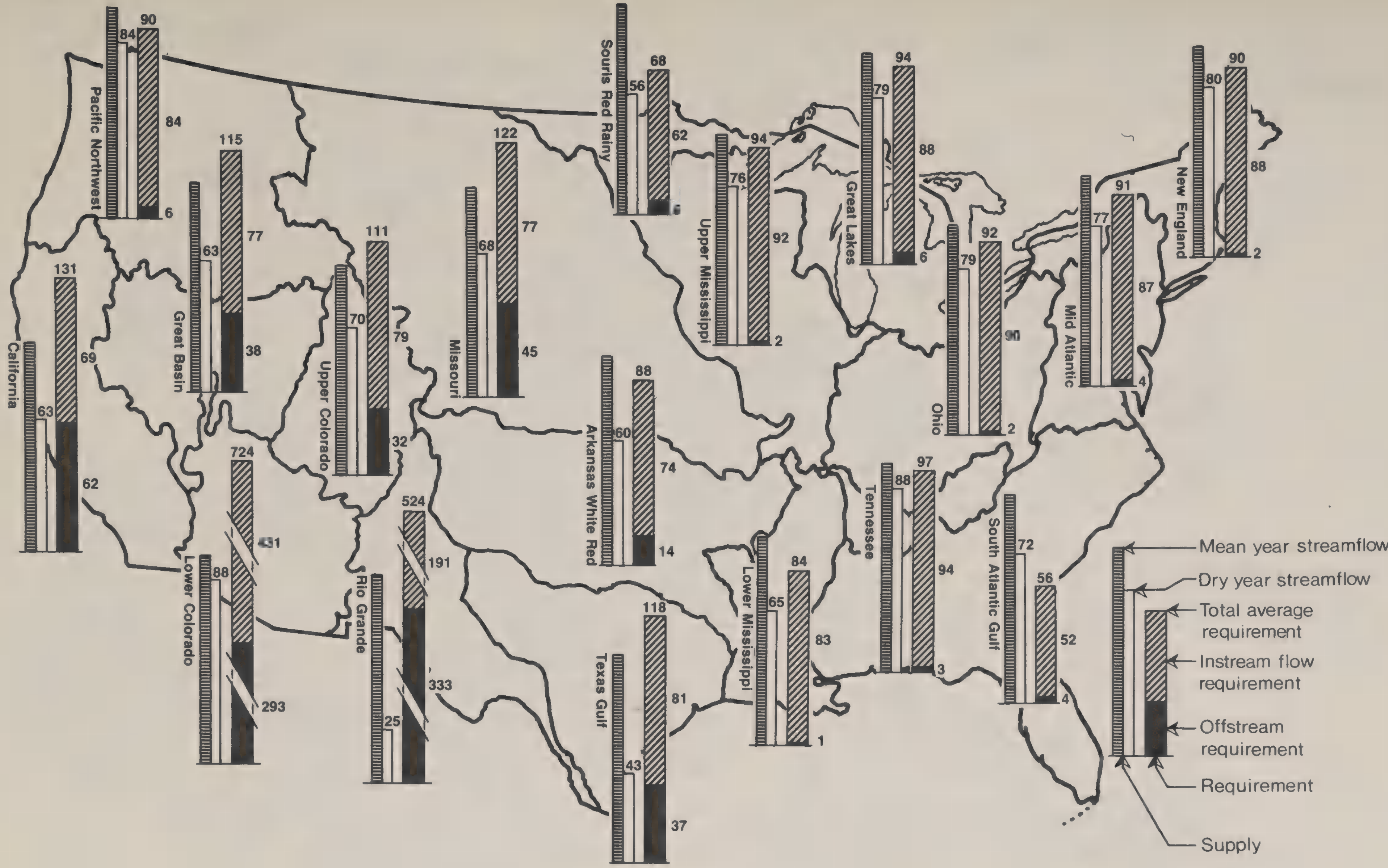


Figure 3C-6.--Comparison of water supply and water requirements. Mean streamflow is always 100%. Dry year streamflow and instream and offstream requirements are expressed as a percentage of mean streamflow.

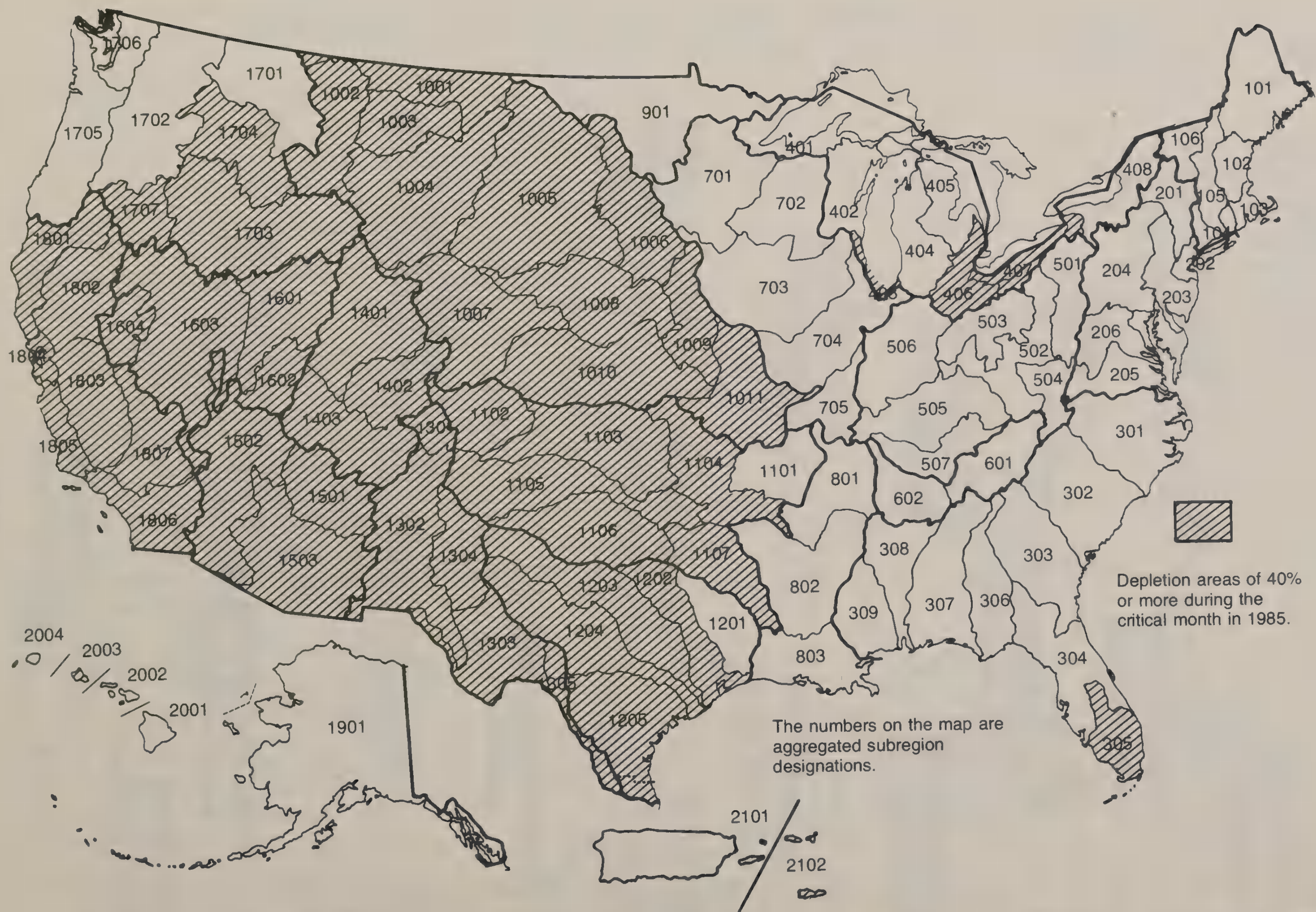


Figure 3C-7.--Projected water-short areas (40% depletion) during critical average months, 1985. Source: U.S. Department of Agriculture. 1978. Report on technical assistance for water conservation in water-short areas.

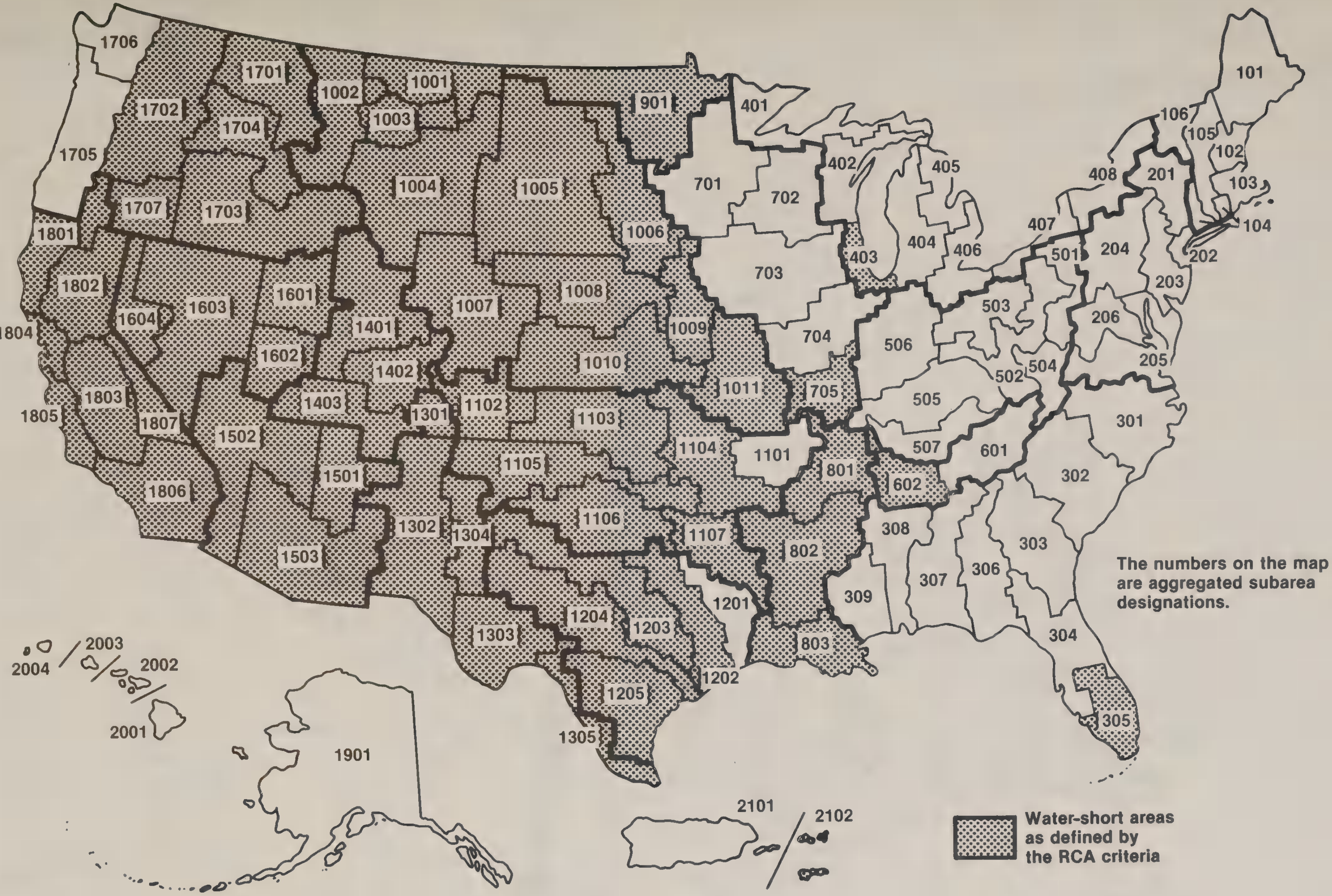


Figure 3C-8.--Hydrologic units designated as water-short.

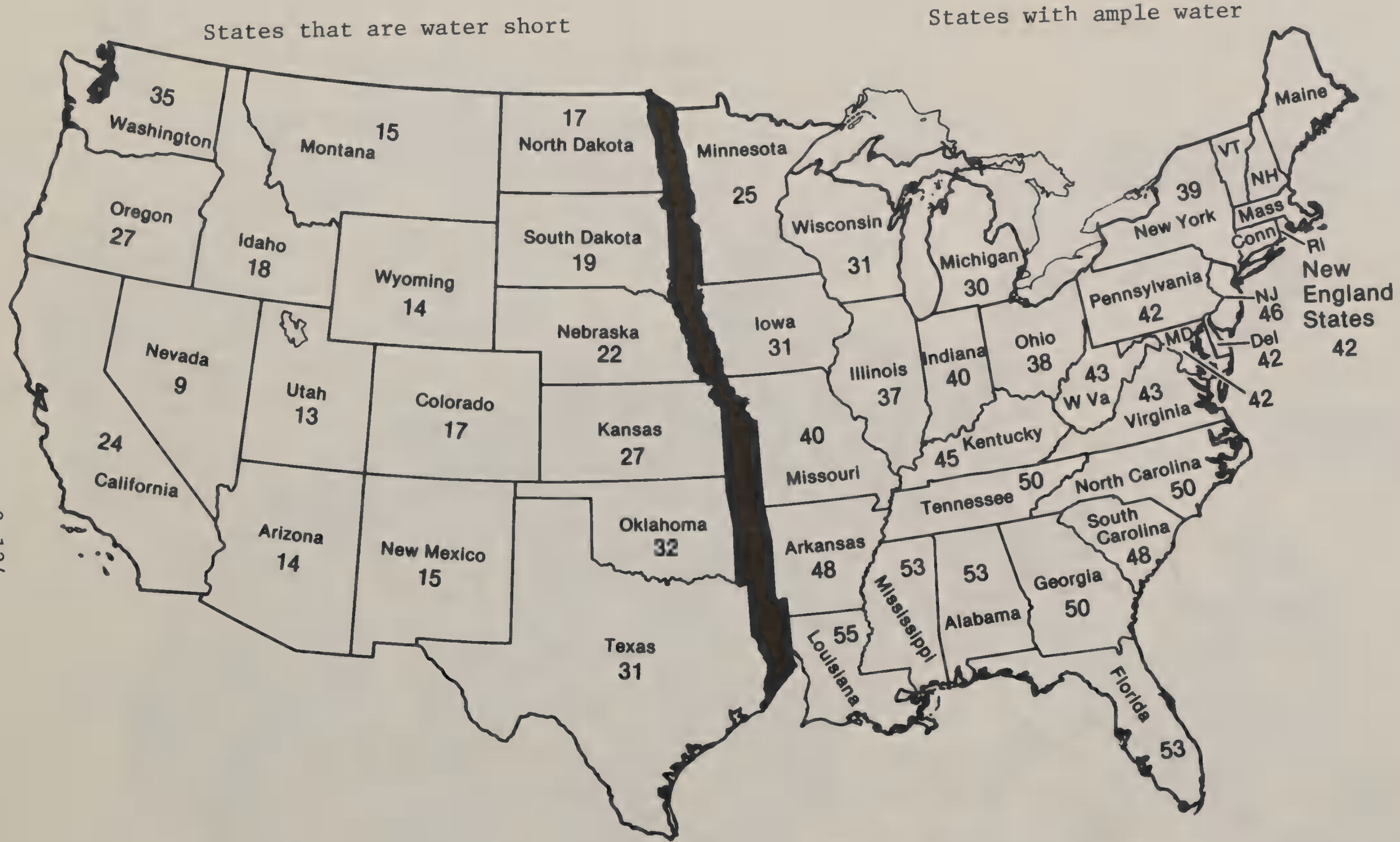


Figure 3C-9.--Mean annual precipitation (inches) by state in the conterminous United States.

yield probably exceeds 400 billion gallons per day. One-third to one-half of the United States is underlain by aquifers capable of yielding 50 gallons per minute or more to wells. Ground water withdrawals account for 24 percent of total fresh water withdrawals. The degree of dependence on ground water varies by location (fig. 3C-10). About 80 percent of all United States municipal water systems are supplied by wells. Most of the rural population depends on ground water sources.

The largest use of ground water is for irrigation--69 percent of the 92 million acre-feet withdrawn (in normalized 1975). An estimated 23 million of the 92 million acre-feet withdrawn were ground water overdrafts. In areas where less than 30 of 100 gallons withdrawn are recharged, withdrawals will become impractical within the next 30 years. These areas are indicated "most critical" in figure 3C-11.

Continued ground water withdrawal in excess of natural recharge eventually exhausts the usable water table, diminishes spring flow and streamflow, causes subsidence and fissures, and allows salt water intrusion into fresh water aquifers in tidal areas. Although there are large reservoirs of ground water that can be feasibly withdrawn, recharge from precipitation is inadequate for replenishment in some areas. Unless there is adequate recharge and water available for percolation is at least equal to withdrawals, there will be ground water mining (see glossary). In many arid and semiarid regions, agricultural production is based on ground water mining and therefore cannot be sustained indefinitely.

In many areas that have declining water tables, irrigation activities will be abandoned before the water is exhausted because of the increasing cost of bringing it to the surface. The severe and continuous decline of the water table in the high plains area of Texas, for example, is the result of decades of pumping for irrigation. Large areas of irrigated land were abandoned when high pumping lifts and sharp increases in prices for fuel to run the pumps made continued production uneconomical (USDA, 1979).

In the critical ground water depletion areas, an average 68 bgd of water are withdrawn from surface and ground water supplies for irrigation. About 53 percent of this comes from ground water sources. Assuming that ground water mining is about the same portion of the total for irrigation as it is for other uses, an average of 15 bgd are being mined for irrigation. About 15 percent of the yearly $10.2 billion value of crop production in these areas can be attributed to irrigation with ground water overdrafts.

The Gila River Basin in southern Arizona and western New Mexico is an example of a water-short area that has severe ground water problems (EPA, 1979). This basin encompasses an extensive agricultural area. Irrigation represents about 90 percent of total water withdrawals. Surface water outflow from the basin is negligible. The economy of the region is supported by mining ground water. Table 3C-3 compares overall water use with the available supply for the Gila Basin. Ground water mining provided more than 55 percent of the total supply in 1975. In order to prevent ground water mining, water supply and use would need to be balanced by either a reduction in use or an increase in supply. If the adjustment were to be made only by agriculture, avoiding ground water mining would require the amount of land irrigated be reduced to

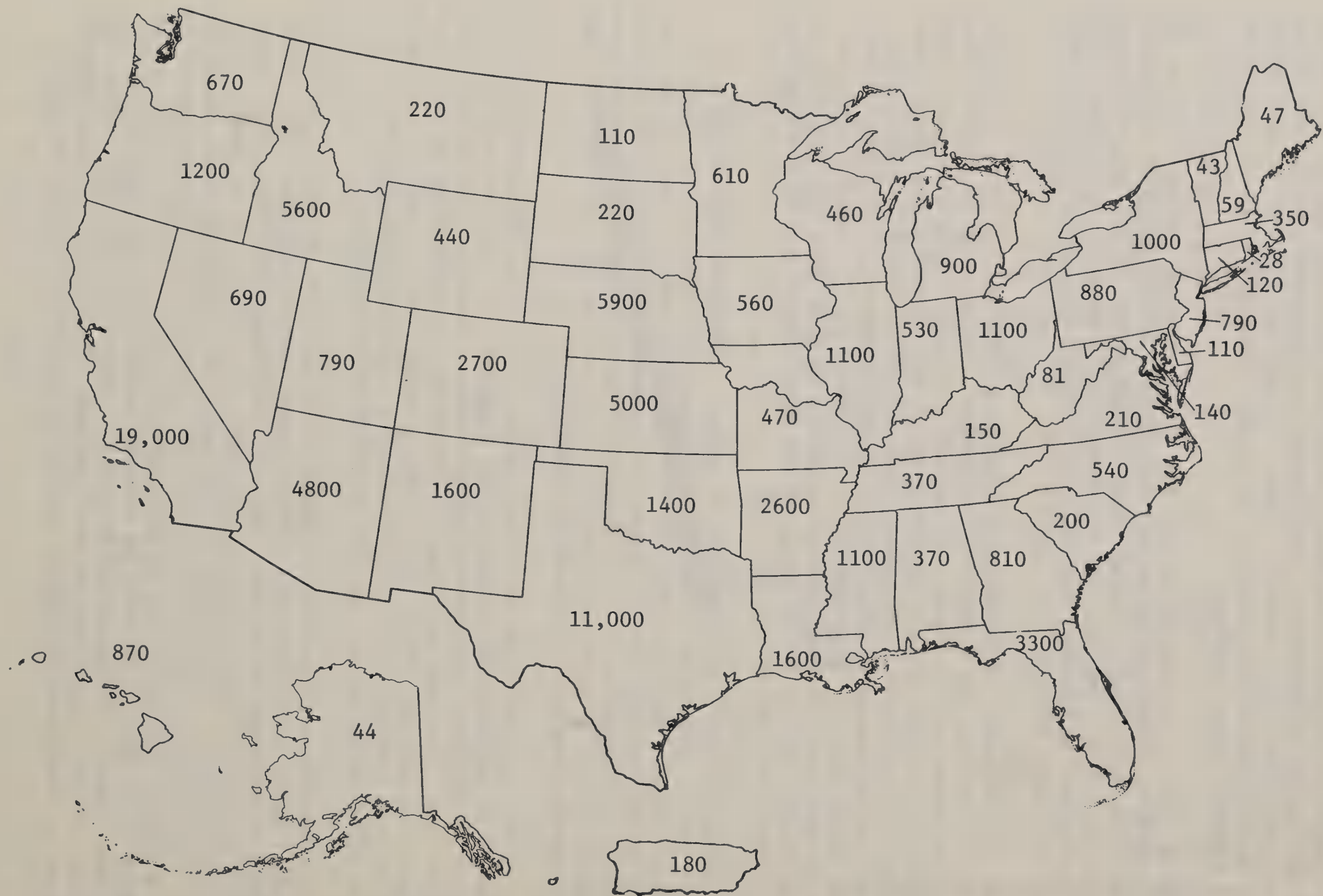


Figure 3C-10.--Ground water withdrawals in the United States in 1975 (millions of gallons per day). Source: Task Force 2B. 1979. Ground water supply, federal-state cooperation. Federal Water Policy Initiatives: Environmental Quality and Resources Management.

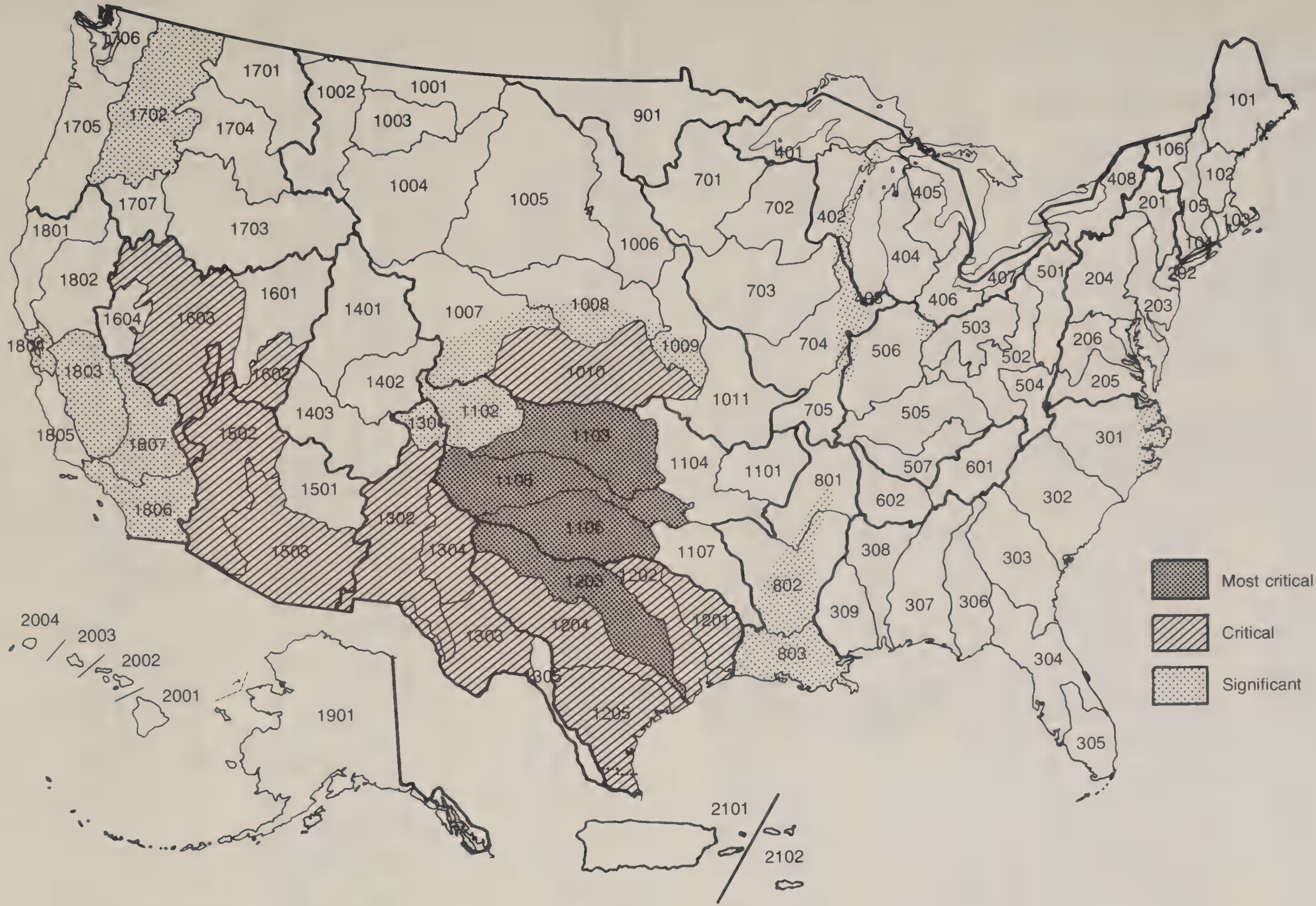


Figure 3C-11.--Areas in which ground water withdrawal exceeds natural recharge.

Table 3C-3.--Water availability and water use in the Gila River Basin (ASR #1503) in 1975 and projected for 2000

Availability	1975	2000
	(billion gallons per day)	
Total supply (with mining)	3.8	NA 1/
Total supply (without mining)	1.7	1.7
Surface water	Negligible	Negligible
Net imports	Negligible	Negligible
Net reservoir evaporation	(0.2)	(0.2)
Ground water	1.9	1.9
Ground water mining	2.1	NA 1/

Use	1975		2000 (with mining)		2000 (without mining)	
	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption
Total Use	6.3	3.5	5.7	3.4	2.8	1.7
Irrigation	5.6	3.0	4.6	2.7	1.7	1.0

1/ NA means not available.
Source: EPA, 1979.

about 600,000 acres. If ground water levels continue to decline, economic pressure could put an end to ground water mining because increased pumping costs would make irrigated agriculture less profitable. However, the competition among uses, in conjunction with the extensive mining occurring in the basin, poses a threat to all water uses.

Scope

Given the resource problems and capabilities of the Nation's water supply, certain actions must be undertaken to meet future needs. USDA's role in water supply and conservation should be to minimize the imbalance between supply and demand. This can be done through programs to reduce or minimize the demand for water, by better management of developed water supplies, and by development of new supplies to meet critical needs within environmental and economic limits.

Agriculture is the largest consumer of water, using four times the combined consumption of all other sectors. Water for food and fiber production is of major significance to USDA and of major concern to other users. Focusing attention on the adequacy and dependability of the water supply for a single usage may miss possible shortages for other uses. Even now, demand often exceeds supply in some areas at certain times.

Because agriculture is the largest user of water, variations or changes in agricultural use are highly significant for total water use. Even small adjustments in agricultural water use can have a great effect on the quantity and quality of water available for other uses. Water supply and conservation activities in which USDA participates fall generally into the broad headings of demand management and supply management.

Demand Management.--In considering ways to meet the demand for water, there are basically two approaches available. One way is to increase the productivity of water used so that greater output of crops results from a fixed quantity of water. This would reduce the total amount of water used. Another way is to reduce demand for water in one region so that more is available to another region. There are choices nationally as to where a product is produced. The impact of this approach on people and resources is more regional than national.

To increase the productivity of water, irrigation water conservation measures to reduce incidental losses and minimize quality degradation can be employed. Optimum levels of moisture for crop production should be provided. Farmers can conserve water and still maintain production levels by planting improved crop varieties that consume less water. Reservoir evaporation can be suppressed.

The shifting of production from one area to another can occur in several ways. The market place will do this automatically, but this can adversely affect resources and people. Certain public actions can be taken to bring about desirable adjustments in ways that minimize adverse effects on resources and people.

Supply Management.--Because the economy is dynamic, there will be shifts in water use and land use that require changes in water supplies. Existing localized problems in water supply for agricultural and other rural uses and the expanding or shifting demands for water in the future make improved water supply management important.

Water users should find ways to improve inadequate or unreliable supplies. A number of opportunities exist for improvements in water supply. The overall amount can be increased and supplies in surface and subsurface basins can be better utilized. Weather modification, vegetation and snowpack management, soil moisture conservation, water harvesting, and ground water recharge are all techniques for increasing supplies. Water supply storage, interbasin transfers, and development of ground water aquifers can provide supplies for site-specific purposes. Conjunctive use of surface and ground water, control measures for more timely distribution, and reuse systems can make fuller use of existing supplies.

Focus

Water supplies and their uses vary greatly by location. However, much of the land in the Nation's watersheds is agricultural land. Vegetation on these agricultural lands plays a dominant part in the hydrologic cycle. Water work projects often take place on farmland. Irrigation is the dominant legal use

of water rights. Agricultural interests in water supply, use, and removal prevail nationwide.

Different forms of agriculture are adapted to moisture conditions of different climatic areas. In the humid East, farmers rely on rain for most crops. Supplemental irrigation is sometimes used on high value or specialized crops. In the subhumid and semiarid midcontinent and northwest, farmers and ranchers irrigate or depend on stored soil moisture. In these areas, particularly the Great Plains, precipitation is variable, and the dryland farming and rangeland are vulnerable to severe weather conditions. In the arid southwest, farmers irrigate to compensate for the persistently low moisture, and there would be little chance for crop production without irrigation.

USDA needs to evaluate its supply and demand management activities for water supply and conservation as they apply to the different forms of agriculture.

- Demand management applies in areas where water supplies are scarce and water requirements are larger than yield. These areas are the subhumid, semiarid, and arid areas--the 17 water-short states (see fig. 3C-9). Demand management should be emphasized in areas where requirements exceed supplies and substantial ground water overdrafts are occurring. These areas are in the southern semiarid and arid regions--the 16 aggregated subregions in which 10 percent or more of the irrigation water is from ground water mining (see fig. 3C-11).

- Supply management applies in areas where either the demand or the supply fluctuates widely. Techniques for enhancing supplies should be considered in water-short areas. Soil moisture conservation practices and techniques to develop supplies and to make fuller use of existing supplies should be considered nationwide.

Results of the Analysis

The capability of the water resource is its ability to meet both quantitative and qualitative requirements. The resource's limitations are inadequate volumes or impurities that restrict water use. Comparing offstream and instream uses with the water supply identifies the ability or inability of the resource to meet requirements.

The water resource capability can change as either the quantity or quality of the supply or of the requirements changes. These capabilities can be increased by:

- making more water available
- limiting water requirements
- providing more dependable supplies
- distributing supplies to location on demand.

Potential ways to supply and conserve water vary according to the nature of the water shortage. Table 3C-4 shows these relationships.

One cannot "make" new water, but one can make more water available in a water-short area, by increasing precipitation, by importing water from water-rich areas, or by conserving available quantities. Potential methods of supplying and conserving water are discussed in the following sections.

Weather Modification.--A number of weather modification techniques to increase agricultural production are being studied. These include changes in precipitation, hail suppression, storm abatement, wind reduction, temperature modification, cirrus cloud production, fog production, change in surface albedo, orchard-heating, and lightning suppression (NAS, 1976).

The most promising technique applicable to agriculture is rainfall augmentation by seeding supercooled orographic (mountain-induced) and winter cyclonic cloud systems. However, the capability of cloud seeding to increase precipitation has not been conclusively demonstrated. Although there are claims of cloud-seeding success, analysis indicates that the precipitation

Table 3C-4.--Potential ways to deal with water shortages

Ways to supply and conserve water	Types of water shortage: Scarce supply	Requirement larger than yield	Fluctuating supply	Fluctuating requirement
Add to water supply	X	0	0	0
Capture and retain precipitation	X	0	/	0
Increase water yield	X	0	0	0
Reduce crop water requirements	0	X	0	/
Reduce nonbeneficial evaporation and evapotranspiration	0	X	/	0
Store water supplies	0	0	X	0
Improve distribution systems	0	0	0	X

Key: X-applicable
/-applicable in some cases
0-not applicable

might have occurred anyway. Controlled experiments have established that, even if cloud seeding works, precipitation cannot be increased more than 10 to 20 percent. Increases in precipitation of 5 to 10 percent over large areas could increase agricultural production. But caution is necessary because it is difficult to assess the effects of cloud seeding on atmospheric processes and the resulting impacts on society. The potential of cloud seeding for increasing crop production therefore remains uncertain.

Inter- and Intrabasin Transfers.--Another means of adding to water supplies in a water-short area is to physically import water from another basin. Denver's municipal supplies are augmented by diverting water across the mountains from the Colorado River Basin. New York City's supplies are increased by transferring water from the Delaware River Basin. Water for irrigation in the Platte and Arkansas Basins is imported from the western slopes of the Continental Divide.

An estimated 18.2 million acre-feet per year of water are transferred from one basin to another. Projects to transfer another 5 million acre-feet per year are now authorized or funded. Additionally, quantities of water are diverted within basins.

Interbasin transfers require extensive study of hydrology, engineering, geology, and environmental impacts on a scale significantly greater than traditional water development projects. The legal and political ramifications contribute to the complexity.

Interbasin transfers are costly. The projects are usually large, some delivering millions of acre-feet of water. Rough cost calculations suggest that construction may cost many hundreds or thousands of dollars per acre-foot of water transferred.

Operating costs will reflect the cost of energy consumed during pumping. Interbasin transfers may also require indemnification to water-users who have vested water rights. Even if the water to be diverted is not covered by vested rights, it may have instream value for fish and game propagation, maintenance of ecological balance, and water-based recreation. These environmental costs can be significant.

Even though interbasin transfer of water is one of the alternatives available for dealing with water shortages, it appears to be a less viable approach than other available methods for dealing with drought problems.

Intrabasin transfers usually involve fewer political jurisdictions and are smaller in scope than interbasin transfers. There are no net evaporative losses in humid areas, and the needed carryover is much smaller. The less costly and complex intrabasin transfers may be a viable approach for areas in the eastern states.

Snow Management.--Snowfed streams provide 70 percent of the water supply used in the west. The amount of usable water yielded by snowpacks depends on the amount of snow accumulated and on the rate of melt. Sunshine, temperature, wind, topography, and vegetation influence the distribution and melting of the snowpack (USDA, 1977b).

Conservation of rangeland snow requires the stabilization of falling and blowing snow as soon as possible to reduce water losses from sublimation and evaporation. As much as one-third of the winter precipitation is lost through sublimation during redistribution by wind and through evaporation during the melt season.

Vegetative windbreaks and experimental wood-slat fences can be used to conserve water by trapping snow and shaping snowdrifts. The tall wheatgrass barrier system shows great promise for increasing snow water supplies through snow trapping, with the added bonus of controlling wind erosion. Accumulating snow in deeper packs as a result of barriers tends to prolong the period of snowmelt runoff. Snow fences may accumulate as much as 50 acre-feet of water per mile of fence.

Alpine and commercial timber snowpack zones yield a major portion of the water runoff in western high country. In Colorado, for example, the alpine area produces an estimated 20 percent of the state's water runoff on only about 3-1/2 percent of the land. In California, 51 percent of the total runoff yield is produced in the snowpack of the state's commercial timber and alpine zones (NWC, 1973).

It is possible to manage and selectively thin forest areas to increase snow accumulation or delay or advance melt to regulate the amount of water yield and the timing of delivery. Openings in the forest tend to trap snow, and wind currents redistribute it into the forest where trees shade it. The redistribution of snowpack resulting from the creation of openings in the forest produces increased streamflows because: (1) less water is used to replace soil moisture consumed by the harvested vegetation; (2) snow on the ground melts more slowly than snow on foliage; (3) more snow is deposited in openings; and (4) snow in an opening is exposed to evaporation for a shorter time. Snow in an opening melts more rapidly than snow in the forest, reducing evaporation and transpiration losses.

Management of Soil Moisture Levels.--Deficient soil moisture is the major factor limiting plant growth, particularly on rangeland and nonirrigated cropland in the semiarid northern Great Plains (USDA, 1979).

Increasing available water and the degree of efficiency with which water is used are important. In eastern Washington, each extra inch of stored soil moisture plus rainfall added 5.8 bushels of wheat per acre (USDA, 1977b). An additional 2.9 bushels per acre are produced for each additional inch of stored soil water plus rainfall in the Northern Plains. Data derived from 17 dryland experiment stations in the Great Plains showed that, on the average, an additional inch of stored soil moisture increases spring wheat yields 2.44 bushels per acre and winter wheat yields 2.72 bushels per acre.

Insufficient soil moisture at planting time often limits crop production. Depletion of soil water to the wilting percentage for 6 to 8 days during the tasseling period reduces corn yields 50 percent. Increasing stored soil water is a means of increasing crop production throughout much of the major agricultural producing area of the United States.

Management practices maintain soil moisture levels by directly modifying either the infiltration rate or evapotranspiration rate.

o Fallow--Summer fallow management keeps the land free of vegetation during one cropping season in order to store moisture for crop production the following season. About one-quarter of the rainfall that comes during the fallow season is stored in the soil for future crop use.

o Weed control--Weeds waste soil moisture through transpiration. Timely cultivation, proper use of chemical weed killers, and keeping the land free of weed seed are effective methods of controlling weeds.

o Stubble-Mulching--Maintaining the stubble or crop residue on the surface protects the soil and conserves moisture. Stubble mulching helps to check runoff. It also improves the soil's moisture retention and granular structure and protects it from erosion.

o Adequate Cover--Crops, plant residues, or mulches on the surface of cultivated lands help to prevent erosion and slow runoff, thereby helping to conserve moisture. Proper management of plant cover makes some mechanical conservation measures unnecessary.

o Cropping Systems--The most efficient use of available moisture is often the goal in selecting a crop or cropping system. In order to achieve this, farmers in dry areas must realize that selection of crops with regard to seasonal moisture requirements, timeliness of seeding, and cultivation at the proper time are important. The amount of additional water needed for a particular crop may be lowered somewhat by growing it after another crop that does not exhaust the water supply in the soil. Grasses help to keep the soil in place and make it receptive to water. Sorghum and cotton can withstand dry periods and resume growth when it rains. They yield more if their growth is not interrupted by drought, but they are not total failures in dry years. Water loss through transpiration can be reduced by growing fewer plants per acre. The crop or cropping system can help control the amount of runoff and aid soil moisture retention on sloping land.

o Adequate Fertility--Fertility is essential for the efficient use of soil moisture. If adequate amount of the essential nutrients are available in the soil, plants can make efficient use of limited moisture supplies in the surface layer and extend their roots into the subsoil to utilize moisture stored at greater depths.

o Minimum Tillage--If the land is not tilled or if tillage is held to a minimum, surface soil is not disturbed and, therefore, is more porous and less subject to erosion. Stubble residue remains on the surface and helps to retain water, thereby giving the water time to infiltrate the soil.

o Subsoiling or Deep-Plowing--These practices shatter or disrupt subsurface horizons that restrict the downward movement of water and the penetration of plant roots. This reduces runoff losses and increases the amount of water stored in the soil. The effectiveness of these practices is generally short-lived and depends on the kind of soil and the amount of water to be stored.

o Contour Cultivation--Contour tillage effectively conserves soil moisture when it is used with other good farming practices. Planting across the slope

reduces the amount of runoff and thereby increases infiltration. The capacity of the soil to absorb water is increased by the contour operations.

o Stripcropping--Long, narrow strips of rowcrops alternate with strips of such close-growing crops as small grain, hay, or pasture in the same field. The close-growing crops tend to slow runoff and to give water time to enter the soil.

o Terraces--Terracing is similar in concept to contouring. Large earth ridges are constructed across a sloping area to intercept runoff water and allow it to infiltrate the soil.

o Range-Pitting--This technique involves scooping out shallow discontinuous pits in order to capture runoff and concentrate moisture which would otherwise be lost.

o Water-Spreading--If the relief of the land limits the collection and diversion of runoff water from higher land for use by crops in lower areas. Diversions or terraces may be laid out to collect, convey, and spread the water. Land-leveling, the reshaping of the land surface, can improve the uniformity of water application and distribution.

o Cultivation Practices--Tile drains, open ditches, and waterways safely remove excess water. These drainage practices reduce the amount of quick runoff in humid areas and increase the storage capacity of the soil. The timeliness of field operations, application of fertilizers, supplemental irrigation, selection of crop varieties, plant populations, and row spacing all affect the soil condition and the soil-water-plant relationship.

Water Harvesting.--Water harvesting is the collecting and storing of precipitation runoff from areas treated to reduce intake. It has been practiced for several thousand years (USDA, 1977b). This method is receiving renewed attention for increasing available water supplies in many areas. Intake reduction (water harvesting) is accomplished in a number of ways, including smoothing, compacting, shaping, and using chemical or physical sealants. Several approaches to storing the harvested water have been investigated, such as pits, bags, and tanks.

Water harvesting permits use of rangeland that previously was unusable because drinking water supplies were inadequate. Water harvesting can also supply water for wildlife. A modification of water harvesting is runoff farming, where water from one area of land is directed to another area to increase crop growth. Water harvesting may also have potential for collecting water for farmsteads and small rural communities.

Manipulation of Vegetation.--Trees and other vegetation affect the water balance of a drainage basin in two ways. First, branches and leaves intercept up to 30 percent of all precipitation, which evaporates without adding to soil moisture. Second, roots absorb large volumes of soil water, which is transported through the stem and lost through the leaves as transpiration. Reducing the density of vegetation is the most efficient way to reduce evapotranspiration losses.

Increases in streamflow after cutting forests have been demonstrated in many parts of the country. Watershed research during the past 40 years shows that water yield from headwater streams can be augmented by intensive forest management (table 3C-5).

Table 3C-5.--Summary of potential increases in water-yield from intensive forest management

Area	Expected annual yield increase 1980	2000	2020	Maximum possible
	(million acre-feet)			
Northeast-------	0.27	0.90	1.50	3.9
Southeast-------	0.23	0.70	1.20	3.1
Northwest-------	1.00	3.00	5.00	8.0
Rocky Mountains-	0.50	0.80	1.10	2.4
Southwest-------	(1/)	(1/)	(1/)	(1/)

1/ Depends on programs to convert chaparral to shallow-rooted species.

Reducing Crop Requirements.--Quantities of soil moisture needed for plant growth and volumes of water diverted for irrigation can be reduced by converting irrigated land to dryland and limiting planted acreage according to available supplies. Farmers can also plant crops that use less water, grow drought-resistant varieties, stress plant growth, and adopt such practices as lower plant population, different row spacings, and modified fertilizer applications.

o Limiting Nonessential Cropping in Water-Short Areas.--In planning land use, it is necessary to determine the permissible levels of plant or animal populations and the necessary amount of soil moisture in light of any precipitation deficiencies. Land use planning may affect cropland and pastureland management by directing the development of various levels of commodity production (agricultural patterns), by stimulating the retirement of marginal lands, and by encouraging flexibility and adjustments in cultivation practices.

Humans depend on about 15 plant species for most of their food. None of these species can survive in arid regions without irrigation. Long-season beans and peanuts are poorly suited to semiarid areas because of their high water requirement. Wheat, short-season corn, barley, oats, grain sorghum, peas, millets, and potatoes are more successful because they have shorter growing seasons and lower total water needs. Millets can be grown where water is inadequate for grain sorghum, and grain sorghum can be raised in areas where corn will not grow.

Shifting crops that use large amounts of water to rainfed areas could change agricultural production patterns enough to alleviate some water shortages. For example, the 12.6 million acres of irrigated hay and pasture in the 17 western states consume 21.7 million acre-feet of water per year--an average of almost 2 acre-feet of water per acre. This compares to an average of 1.6 acre-feet of water per acre on all 41 million acres irrigated in these same

17 western states. About 1.1 million acres of rice, the largest water-using crop, are grown in semiarid regions.

Serious limitations on the water supplies remaining for development in heavy water use areas and society's desire to maintain environmental quality may result in policies that curtail certain agricultural activities. Such policies could affect the allocation of resources, the production techniques employed, and the location of agricultural activities. Production would likely be adjusted to favor regions that can more economically cope with policy restrictions (table 3C-6). For example, if water for irrigation were to be severely curtailed in the West, much of the production would shift to the humid agricultural areas of the East.

Table 3C-6.--Regional production patterns for agriculture

Water Resources Regions	Irrigated land 1975	Irrigated land 2000 Most likely	Irrigated land 2000 Water restraint	Irrigation Water Use 1975	Irrigation Water Use 2000 Most likely	Irrigation Water Use 2000 Water restraint	Percent change
	(million acres)			(million acre-feet)			
Missouri	9.7	11.5	9.2	14.2	17.6	13.2	-25
Arkansas-White-Red	4.8	5.5	4.1	7.0	7.1	5.8	-18
Texas-Gulf	4.8	3.4	2.7	9.3	6.1	5.3	-13
Rio Grande	2.0	1.9	1.7	3.9	3.6	3.3	-9
Upper Colorado	1.4	1.6	0.6	2.2	2.7	0.8	-69
Lower Colorado	1.3	1.2	1.2	4.0	3.7	3.7	-1
Great Basin	1.7	1.6	1.3	3.2	3.2	2.5	-22
Columbia-N. Pacific	6.2	7.7	5.2	11.0	13.2	7.5	-43
California-S. Pacific	8.7	10.1	9.4	24.3	26.3	24.8	-6
Remainder-of U.S.	4.7	7.9	7.9	7.3	9.0	5.3	-41
U.S. Total	45.3	52.4	43.3	86.4	92.5	72.2	-22

Source: USDA, 1977c.

The acreage in dryland farming or in pasture would increase in the West. The yields would tend to be lower because less water would be available for irrigation, causing a reduction in the number of acres irrigated. Because lower yielding lands in other regions of the United States would come into production rather than the more productive irrigated land, more acres would

have to be harvested. Cropping would be more intensive on erodible land. The increased use of erodible lands would require more use of conservation and minimum tillage practices. Although the national net agricultural earnings and employment level would not change significantly, some regional changes could be expected.

o Planting Drought-Tolerant Plant Varieties.--Plant breeding programs have developed drought-tolerant cultivars that will grow where climate previously precluded agricultural production. For example, the development of high-yielding, short-season plants that could grow farther north in Minnesota increased the state's soybean production from 2 percent of the Nation's total crop in 1944 to 8 percent in 1973. Improved wheat varieties were, in part, responsible for the rapid expansion of arable agriculture into the Great Plains in the early part of this century. The change in the varieties of wheat grown in Nebraska probably reduced the impact of drought in the 1950's.

Improved crop varieties help to continue production despite unfavorable weather. For example, if corn hybrids are given sufficient nutrients they produce root systems that can extract soil moisture to the wilting point to a depth of nearly 5 feet. In Iowa in 1975, this ability counteracted the effects of a severe drought and helped maintain an average corn yield for the state of 90 bushels per acre.

The development of hybrid corn varieties has resulted in soaring yields, especially since the early 1950's. The development of high-yield dwarf varieties was heralded as the "green revolution" of the 1960's. Current research seeks to find nutritious high-yield varieties that adapt to varying weather conditions.

Although much research has been conducted on drought-resistant, high yield varieties, more is needed. Many of the revolutionary high-yield varieties depend on more, not less, water and fertilizer. The use of such varieties decreases the stability of the agricultural system and makes it more susceptible to major climatic variation. Therefore, combining high yield with drought resistance in crop varieties should be an important goal in agriculture.

Some crops can undergo periods of stress without severe reduction in yield. Water application should strive for maximum yield per unit of water, rather than for maximum yield per unit of land. Farmers in water-short areas should consider selecting crops with deep root systems. Combined evaporation and transpiration is less in a thinly seeded crop than in a thickly planted crop.

o Using Decisionmaking Models and Information.--The effectiveness of decisionmaking models and information on water supplies depends on:

1. the ability of the information program to reach users and the extent of the information coverage,

2. the willingness and the ability of agricultural and urban managers to adapt operations or make changes to save water, and

3. the validity of the information.

The farmer relies on current weather assessment, water supply and market information, yield response data, and other information to make management decisions. It has been estimated that effective management by farmers results in up to 50 percent higher yields on major crops. Decisionmaking models, using careful systems analyses and possibly simulation techniques, could help other producers to reach this level. Technically sound responses to soil data inputs are needed in such models.

1. Decisionmaking models.--The farmer today is faced with the extremely difficult problem of choosing the best farming strategy from among many alternatives. The choice is complicated by weather, water availability, market conditions, farm technologies, and the complexities of government policy. The development of normative models for decisionmaking to aid agricultural or urban managers may help farmers attain optimum levels of water use. Currently, some irrigators are already using computer models to help them apply water efficiently.

2. Decisionmaking information.--Farming decisions should be based upon the best information available, including data on current and potential farm operations, soil, crop responses to soil moisture, and water supply availability. The value of water supply forecasts depends on their accuracy and the flexibility of the agricultural producer to adjust his activities. A farmer can respond to water supply forecasts by varying the kinds of crops, the plant populations, and the acreage planted. If water supply is a significant variable in planning decisions, the plan that maximizes expected income is selected.

There are two distinct ways of managing resources in response to water supply forecasts. In the first case, the farmer does not control the water supply and alters farm operations to make use of available soil moisture or natural stream runoff. Crops may be changed to early maturing varieties or to kinds with a shorter growing season to avoid late season drought. The farmer can also select drought-tolerant crops that possess good recovery ability following periods of stress and can seed plant populations and adopt fertilizer use to take advantage of expected moisture. Forty pounds of winter wheat seed is commonly used on dry areas, whereas 120 pounds could be used on irrigated areas.

The second way to manage resources involves the use of reservoirs to store and control the release of available water. The farmer is not as concerned about stress periods, because water may be applied at will. The total amount of water available for the season and the market prices determine which crops and how many acres should be planted. In dry years, the farmer will either concentrate water on a small acreage of crops using large amounts of water, or change production to drought-resistant crops. In wet years, he may expand the acreage of crops using large amounts of water.

The producer of such perennial crops as fruit has less flexibility. Only long term forecasts will affect acreage or crop decisions. The value of seasonal forecasts lies in the ability to plan ahead for alternate water sources to sustain orchards and vineyards in spite of drought. A similar problem exists

for producers of other crops who invest heavily in crop-specific machinery and lack capital for flexibility.

Water supply forecasts based upon snow surveys help farmers use water more effectively on more than 10 million acres in 11 western states and Alaska. Snow water content and other hydrometeorological data are measured at about 1,600 sites. The specific objectives of the survey program are:

1. to provide advance information on seasonal water supplies for streams which derive most of their runoff from snowmelt;

2. to help farm operators, rural communities, and municipalities to apply water supply forecast information; and

3. to provide hydrometeorologic data for regulation of reservoir storage and management of streamflow.

Water supply forecasts have played a vital part in minimizing the impacts of drought on western irrigated agriculture. If there is advance warning of an impending critical water supply problem, a farm operator can decrease crop acreages, adjust the types of crops, improve the efficiency of irrigation, or try to develop temporary sources of supplemental water. During the western drought in 1976-77, serious water shortages were forecast as early as January, giving farmers ample time to plan ways to minimize the drought's effects.

Irrigation Water Use and Management.--Some irrigation water is consumed by crops through evapotranspiration. The water that is not consumed is often referred to as "lost" water. Most "lost" water is returned to the system for reuse, but some cannot be recovered such as irrecoverable ground water and water lost in phreatophyte consumption and evaporation.

Evaporation from water surfaces ranges from about 15 inches in the northeastern U.S. to over 80 inches in the southwest. Prior to reservoir construction, evaporation from water surface reservoirs exceeds the amount of evapotranspiration from the soil and vegetation in the subhumid, semiarid, and arid areas. The net evaporation is "lost" to any water user. It cannot be recovered. Irrigation water management and selected measures, and to a lesser extent reservoir location and management, can reduce evapotranspiration and evaporation.

Irrigation practices and methods vary even within states, because of varying water supplies and economic conditions. However, irrigated cropping programs are similar in areas with similar climatic conditions. Some of the primary considerations in development of irrigation are climate, amount of precipitation available, and the length of the growing season.

Climatic conditions determine not only what crops can be grown on dryland, but also which crops can be grown with irrigation and the amount of irrigation water required. The average growing season and the average annual precipitation for all areas of the United States are available in the "Climatic Atlas of the United States."

Other factors affecting irrigation development are the soil, topography, available quantity and quality of surface and ground water, and competitive uses for available water. These factors and others characterize the thirteen irrigation areas in the conterminous United States (fig. 3C-12). Table 3C-7 describes the characteristics of the six areas in the West .

Irrigation systems are designed to supply water for crops so that yields are not limited by water shortages. The crop root zone--that depth of soil (commonly 1.5 to 6 feet) in which roots are actively growing--provides a reservoir to store water from irrigation and precipitation until it is used by the crop. Water which infiltrates into this reservoir but exceeds its water capacity will percolate below reach of the roots and enter the ground water system.

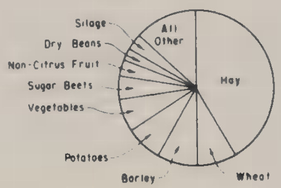
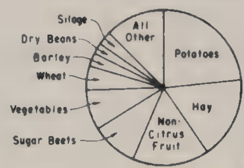
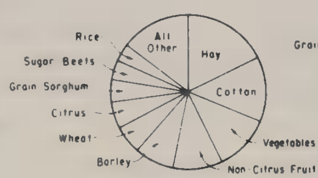
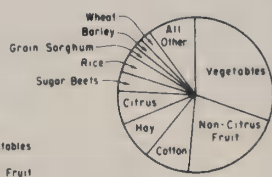
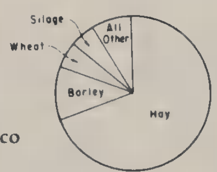
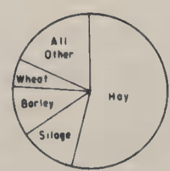
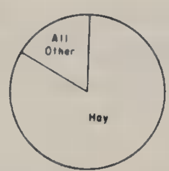
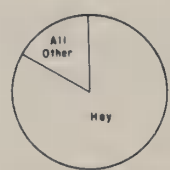
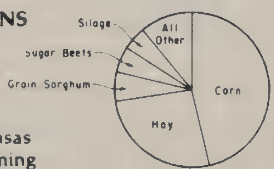
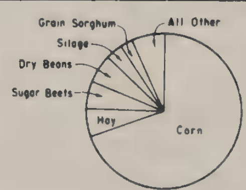
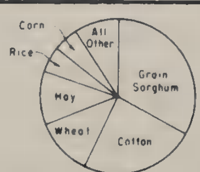
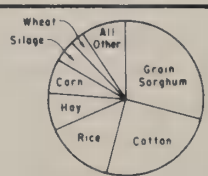
Surface irrigation is used on approximately three-fourths of the Nation's irrigated land. The method is so named because the water flows over the surface of the irrigated field and infiltrates to fill the root zone. Surface runoff may be relatively unchanged in quality and readily salvaged for reuse. Therefore, systems with runoff do not necessarily represent poor irrigation.

Use of sprinkler irrigation systems is increasing rapidly in most areas of the United States. Sprinklers--especially center-pivot, self-propelled sprinklers--are attractive to farmers because they require little labor. Although most sprinkler systems are operated by pumps, there are a few that operate on gravity pressure.

Application with properly managed sprinklers is efficient if water is applied uniformly at rates less than the soil intake rate. This prevents runoff. Under many conditions, total water consumption is not significantly greater for sprinkler irrigation than for surface methods. Wind drift and evaporation losses, however, can be about 25 percent of the water applied when there is high wind, high temperature, and low humidity. Most sprinkler systems are operated at pressures ranging from 30 to 80 pounds per square inch. Pressurizing the water to this level requires energy consumption equivalent to lifting the water, by pumping, 70 to 185 feet.

In the last 10 years, farmers have begun to use drip (trickler) irrigation systems on orchards, vineyards, vegetables, and sugar cane. Drip systems use small plastic tubing, typically one-half inch in diameter, to transport water to the desired point of infiltration. There the water is slowly applied to the soil through emitters or perforated tubing. The rate of application is usually 1 to 4 gallons per hour per emitter. Drip systems operate at lower pressures than sprinklers and can be designed to achieve high uniformity. Runoff and deep percolation can be almost entirely eliminated. Evaporation is greatly reduced when drip irrigation is applied to widely spaced crops such as those in orchards or vineyards, because only a small percentage of the soil surface is wetted. The total irrigation requirement for such crops can be reduced below that occurring with surface or sprinkler irrigation. If drip systems are used on close-growing crops, there is no equivalent reduction in consumption use. Drip systems are usually highly automated, making light frequent (perhaps daily) irrigations practical. With drip systems, however, salt may build up in the soil over a period of time.

Table 3C-7.--Irrigation characteristics in the 17 western states (USDI et al., 1979)

Area	Relative acreage of major irrigated crops grown	Relative value of major irrigated crops harvested	Irrigation situation	Crop growing season (days)	Consumptive irrigation requirement for alfalfa[2] (acre-ft/acre)
NORTHWEST Oregon Washington Idaho	 14%[3]	 12%[4]	Intermediate Valley[1]	120-200	2.3-2.7
			Mountain Meadow	80-120	1.3-1.7
SOUTHWEST California Arizona Southern New Mexico Southwest Texas	 22%[3]	 33%[4]	Lower Valley[1]	200-365	3.0-6.2
			Intermediate Valley	100-200	1.9-4.2
			Plains (with onfarm water supply)	200-365	3.0-6.2
INTERMOUNTAIN Nevada Utah Northwest New Mexico	 4%[3]	 1%[4]	Intermediate Valley[1]	120-200	2.0-3.7
			Mountain Meadow	80-120	1.3-1.7
ROCKY MOUNTAIN Portions of: Colorado Wyoming Montana Idaho Northern New Mexico	 5%[3]	 1%[4]	Mountain Meadow[1]	80-120	1.2-1.7
			Intermediate Valley	100-150	2.0-2.6
NORTHERN GREAT PLAINS Montana North Dakota South Dakota Nebraska Northern Kansas Eastern Wyoming Eastern Colorado	 20%[3]	 21%[4]	Plains (with onfarm water supply)[1]	160-240	1.5-2.0
			Intermediate Valley	150-200	1.5-2.0
SOUTHERN GREAT PLAINS Southern Kansas Oklahoma Texas Eastern New Mexico	 24%[3]	 12%[4]	Plains (with onfarm water supply)[1]	180-330	1.4-4.7
			Lower Valley	180-330	1.4-4.7

[1]Indicates the major irrigated acreage in the area.
[2]A widely grown crop — data indicates relative irrigation water requirements among areas. However, production per acre varies also.
[3]Total U.S. irrigated acreage.
[4]Total value of U.S. irrigated crops.

Table 3C-7.--Irrigation characteristics in the 17 western states (USDI et al., 1979)--Continued

Water source	Irrigation methods	Present average irrigation efficiencies (percent) Onfarm	Off-farm Conveyance	Competitive uses	Instream flow	Water quality
70% surface 30% ground water	About equally divided between sprinkler and surface (border, furrow, basin, corrugations), some trickle	25-70	60-95	Hydropower, recreation, instream flows, new irrigation and navigation	Seasonal inadequacies in streams and estuaries	Seasonal temperature fluctuations, dissolved gases and sediment
100% surface	Wild flood	25-40	55-70	Recreation and instream flows	Inadequate streamflows in dry years	Excellent
80% surface 20% ground water	Surface (border, basin, corrugations, furrow), sprinkler and some trickle	50-70	70-95	M&I, recreation, estuary inflow, instream flows, new irrigation	Severely depleted streams and estuary inflows	Salinity increases downstream
90% surface 10% ground water	Surface (border, contour ditch, furrow and corrugations)	45-65	70-80	M&I, hydropower, recreation and instream flows	Seasonal inadequacies	Good
100% ground water (severe overdraft)	Surface (border, basin, corrugations, furrow) some sprinkler and trickle	60-70	none	M&I and new irrigation	Inadequacies	Ground water good to poor
80% surface 20% ground water	Surface (border, contour ditch, furrow, corrugations), some sprinkler	35-50	70-95	Industry, recreation and instream flows	Seasonal inadequacies	Salinity increases downstream
100% surface	Wild flood	25-50	50-80	Recreation and instream flows	Localized areas with inadequate flows in dry years	Excellent
100% surface	Wild flood	25-50	50-80	Recreation, instream flows and transbasin diversion	Localized areas with inadequate flows in dry years	Excellent
95% surface 5% ground water	Surface (border, contour ditch, corrugations and furrow), some sprinkler	40-55	50-95	Power generation, recreation and instream flows	Seasonal inadequacies	Salinity increases downstream
90% ground water 10% surface (overdraft)	About equally divided between sprinkler and surface (furrow)	40-65	none	M&I and new irrigation	Seasonal inadequacies	Ground water good
90% surface 10% ground water	Surface (border, contour ditch, corrugations and furrow), some sprinkler	40-55	40-90	Industry (power generation), recreation and instream flows	Seasonal inadequacies	Warm summer temperatures and sediment problems
95% ground water (severe overdraft)	About equally divided between sprinkler and furrow and basin	50-70	none	M&I and new irrigation	Seasonal inadequacies	Ground water good to poor
50% surface 50% ground water	Surface (furrow, border and basin), some sprinkler	65-75	80-95	M&I, estuary inflow, instream flows and recreation	Severely depleted streams and estuary inflows	Low to high salinity

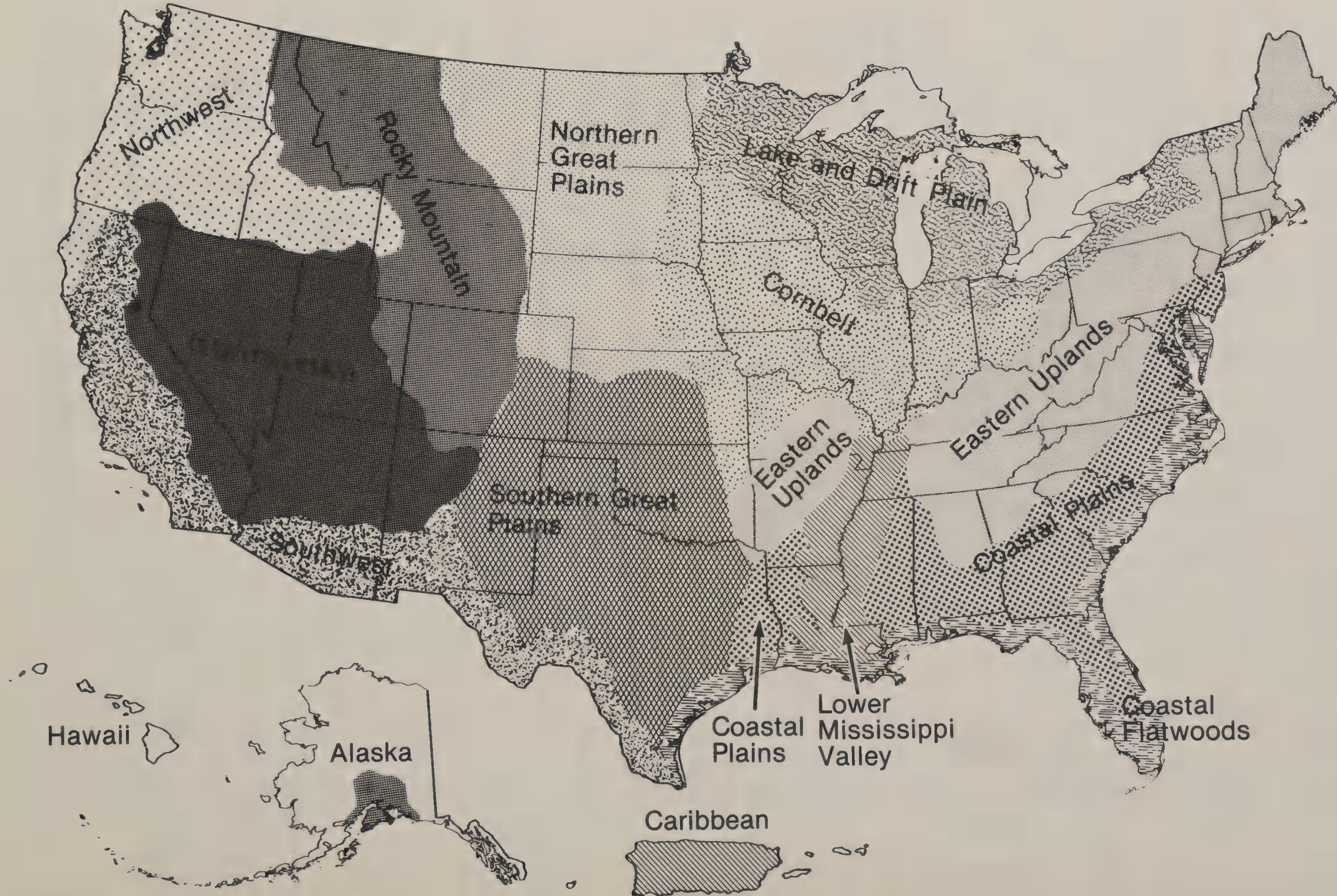


Figure 3C-12.--Irrigation characterization areas. (USDI et al., 1979)

Irrigation Management Problems.--The four situations described below illustrate irrigation water management problems.

o Mountain Meadow Irrigation.--Mountain meadow irrigation is practiced in areas of high elevation that experience a very short growing season. Soils are often shallow, limiting water-holding capacity of the root zone and making land leveling difficult. Irrigation is limited to grass pastures and haylands. The water supply is diverted from streams by temporary dikes and crude diversion structures. Water is usually applied to fields by wild flooding.

o Intermediate Valley Irrigation.--This type of irrigation is used in valleys located between high mountain meadows and the lowlands or plains. Intermediate valleys have a moderate growing season which limits crop production and economic capability. Water is usually supplied to these areas from natural runoff that is often stored in reservoirs. Water is diverted and transported to irrigated lands by gravity diversion structures and conveyance systems. Most conveyance systems consist of open, unlined waterways. Conservation measures such as weed control and water measurement are underdeveloped. Farmers generally use surface techniques to apply water to fields. The most common surface methods are graded border, contour, graded furrow, and corrugation. Most irrigated land is shaped to some extent; however, steep grades exist and are often not effectively irrigated. Sprinkler irrigation is increasing in some areas.

o Lower Valley Irrigation from Surface Water Supplies.--These areas are intensively cropped because of the longer growing season. Many lands are double-cropped. Irrigation is intense and consumptive use of water per irrigated acre is high. Available water becomes an important factor in crop production. Storage reservoirs are used, and most lower valleys have sophisticated diversion and conveyance systems. Systems employ such features as lined canals, piped distribution systems, and automation. Onfarm systems are also sophisticated. The most common methods of irrigation are graded or level border and contour levee. Advancements in drip irrigation are being made. Farmers use onfarm tailwater recovery systems when water supply is limited or piped from ground water. Thus, there may be little surface return flow.

o Plains Irrigation from Onfarm Water Supplies.--Many farms in intermediate valleys and lower valleys and plains are irrigated by pumping water either from a ground water supply or directly from a stream or an onfarm water impoundment. There are usually no off-farm water conveyance facilities. The common methods of water application are sprinkler; surface methods, such as graded furrow; or borders using siphon tubes, gated pipe, and tailwater recovery systems. Irrigation has developed rapidly because of advances in technology, such as high-head pumps, sprinkler irrigation systems, and aluminum and plastic pipe.

Irrigation Water Management Efficiency.--Inefficient management of irrigation has significant effects (table 3C-8).

Water is used by phreatophytes and hydrophytes, by evaporation from spills and tailwaters, and by deep percolation incidental to the irrigation of a crop. These are incidental losses that are not recoverable. Nationally,

23 million acre-feet are irrecoverably lost each year to incidental uses (fig. 3C-13). Crop consumptive use equals only 41 percent of water diversions; another 46 percent returns to surface or ground waters for reuse, leaving only 13 percent irrecoverably lost. Table 3C-9 shows the water budget in 17 western states where there is significant irrigation. It gives crop consumptive use, off-farm conveyance and onfarm efficiencies, gross diversions, incidental losses (uses), and projected future trends (USDI et al., 1979). There are different and sometimes conflicting definitions of irrigation efficiency. It is frequently assumed that if irrigation efficiency is low, much irrigation water is being wasted. This is not necessarily true. Irrigation efficiency definitions used in this report for off-farm conveyance efficiency and for onfarm efficiency are:

- Off-farm conveyance efficiency: The volume of water delivered to the farm, expressed as a ratio or percentage of the volume of water diverted (gross diversion) from a stream or other water supply.

- Onfarm efficiency: The volume of water stored in the soil root zone and used by the crop, expressed as a ratio or percentage of the volume of water delivered to the farm.

The average off-farm conveyance efficiency for the United States was estimated to be 77 percent and the average onfarm efficiency was 53 percent. Figures 3C-14 and 3C-15 show the estimated efficiencies of irrigation in the West.

These current figures on average off-farm conveyance and onfarm irrigation efficiencies do not mean that water now diverted for irrigation can be saved and made available for other uses. Most of the water seeping from or running off the surface of any given irrigation system returns to stream channels or ground water reservoirs where it is available for reuse. Only a portion of the incidental irrecoverable losses can be "saved".

The Sevier River in Utah can be used as an example of how much water could be saved by increasing irrigation efficiency (USDI et al., 1979). The average off-farm conveyance efficiency in the Sevier Basin is 67 percent, and the onfarm efficiency is 45 percent. The Sevier River is one of the most completely consumed rivers in the United States. Of the total precipitation (6 million acre-feet), about 1.1 million acre-feet are delivered to the irrigated area. Outflows to Sevier Lake and other canals and rivers total only 45,000 acre-feet (table 3C-10).

Only 51 percent of the available water supply is consumed beneficially by irrigated crops. Another one-fourth is consumed on nonirrigated wet meadows--a use that also benefits agriculture. The seeming inconsistency between efficiency values and basin utilization is a result of rediversion and reuse of "losses" from upstream irrigators.

Phreatophytes and evaporation from reservoir surfaces consume one-fourth of the water supply for irrigation. This consumption does not directly benefit agriculture. Since reservoirs provide seasonal distribution of water supplies and store water for dry years, the reservoir evaporation cannot be avoided. Theoretically, agriculture or other uses could benefit if part of

Table 3C-8.--Significant effects of inefficient water management by irrigation situation (USDI et al., 1979)

Beneficial	Mountain meadow	Inter-mediate valley	Lower valley	Plains (onfarm water supplies)
Increase in crop yields by extending downstream irrigation	X	X		
Maintenance of wetland wildlife habitat	X	X	X	X
Maintenance of streams for non-agricultural beneficial use	X			
Adverse				
Irrecoverable loss of water			X	X
Decrease in crop yields	X	X	X	X
Degrading water quality		X	X	X
Periodic localized over-depletion of streamflow	X	X	X	X
Excessive energy use			X	X

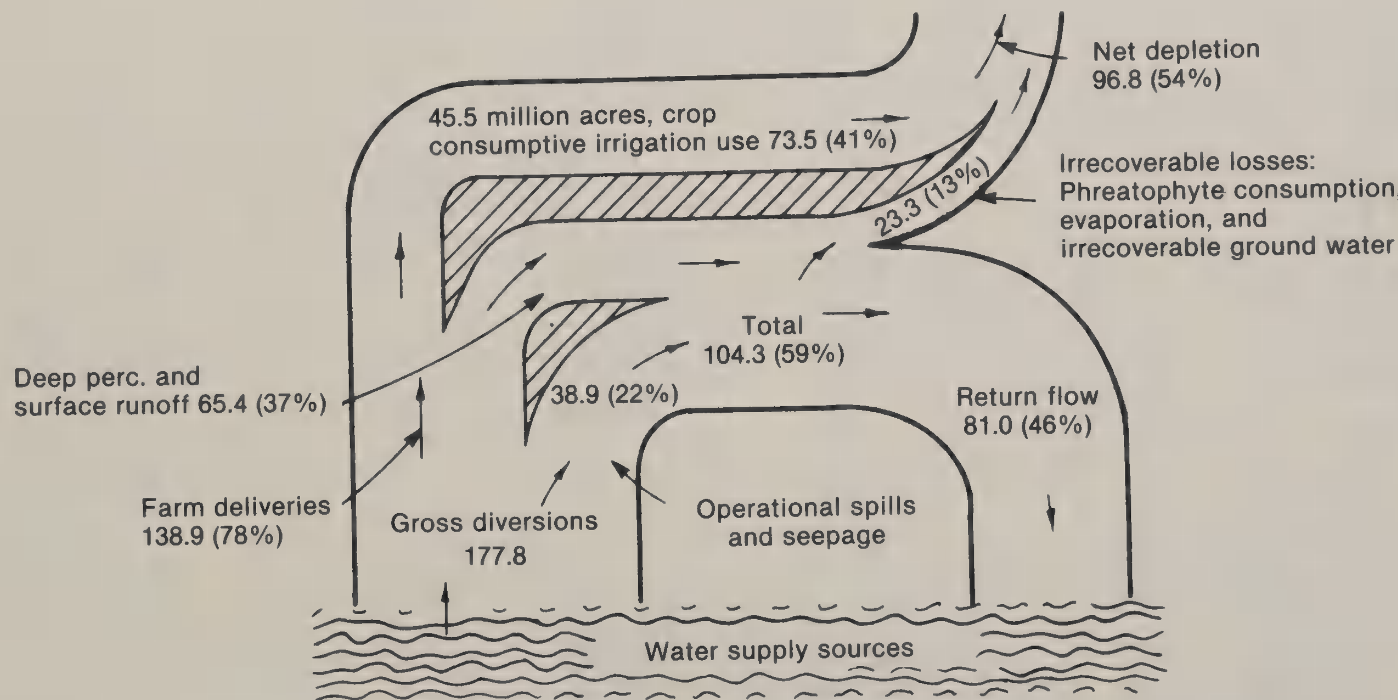


Figure 3C-13.--Irrigation water budget for the United States and Caribbean for a year with normal water supplies, 1975 level of development (water quantities in millions of acre-feet). (USDI et al.,1979)

Table 3C-9.--Water budgets by characterization areas, 17 western states, based on a normal precipitation year--for present situation and two alternative situations in year 2000 (USDI et al., 1979)

Area	Irrigated acreage	Gross diversion	Farm delivery	Crop requirement	Incidental use	Net depletion	Return flow	Conveyance efficiency	Onfarm efficiency
	(1,000 acres)	*(- - - - - - - - - -*		*million acre-feet*			*- - - - - - - - - -)*	*(- - - - - percent*	*- - - - -)*
Present — (1975 base) with 4.3 million acre-feet shortage in meeting crop requirement									
Northwest	5,513	33.3	20.4	8.1	2.9	11.0	22.3	61	40
Southwest	11,216	50.2	41.9	25.7	8.0	33.7	16.5	83	61
Intermountain	2,042	7.5	6.2	2.7	0.9	3.6	3.9	83	44
Rocky Mountain	4,010	17.7	10.9	4.4	1.6	6.0	11.7	62	40
Northern Great Plains	7,941	23.9	18.0	9.1	2.6	11.7	12.2	75	51
Southern Great Plains	10,236	27.1	25.3	15.5	5.1	20.6	6.5	93	61
Total	40,958	159.7	122.7	65.5[1]	21.1	86.6	73.1	77	53
Acre-feet/acre		3.90	3.0	1.60	0.52	2.11	1.78		
Year 2000 — continuation of ongoing program assuming full water supply									
Northwest	5,513	27.5	18.3	9.1	2.7	11.8	15.7	67	50
Southwest	11,216	44.1	39.4	25.8	6.4	32.2	11.9	89	65
Intermountain	2,042	8.5	7.2	3.4	0.9	4.3	4.2	85	47
Rocky Mountain	4,010	18.7	12.3	5.4	1.6	7.0	11.7	66	44
Northern Great Plains	7,941	22.3	17.8	10.4	2.1	12.5	9.8	80	58
Southern Great Plains	10,236	25.9	24.4	15.7	4.3	20.0	5.9	94	64
Total	40,958[2]	147.0	119.4	69.8	18.0	87.8	59.2	81	58
Acre-feet/acre		3.59	2.92	1.70	.44	2.14	1.45		
Year 2000 — installation of program shown in table 15 assuming full water supply									
Northwest	5,513	20.3	15.5	9.1	2.1	11.2	9.1	76	59
Southwest	11,216	39.2	35.2	25.8	4.8	30.6	8.6	90	73
Intermountain	2,042	7.2	6.3	3.4	0.7	4.1	3.1	88	54
Rocky Mountain	4,010	14.2	10.6	5.4	1.3	6.7	7.5	75	51
Northern Great Plains	7,941	17.4	15.5	10.4	1.6	12.0	5.4	89	67
Southern Great Plains	10,236	22.8	22.0	15.7	3.0	18.7	4.1	96	71
Total	40,958	121.1	105.1	69.8	13.5	83.3	37.8	87	66
Acre-feet/acre		2.96	2.57	1.70	0.33	2.03	0.92		

[1] 4.3 million acre-feet shortage.

[2] Irrigated acres for year 2000 were held constant to better show effects of water conservation measures. See Second National Water Assessment report for projections of irrigated acreage.

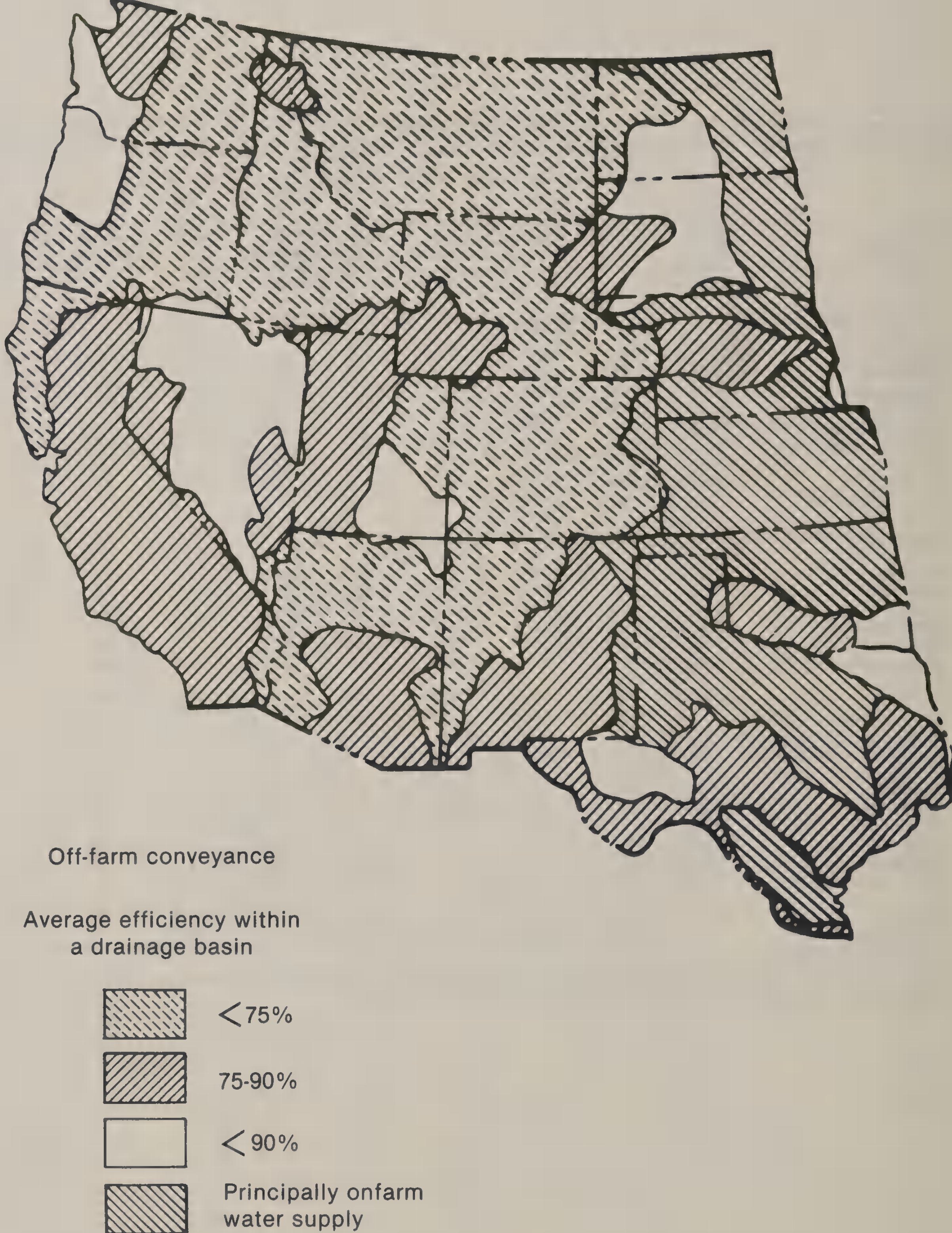


Figure 3C-14.--Off-farm conveyance efficiencies. (USDI et al., 1979)

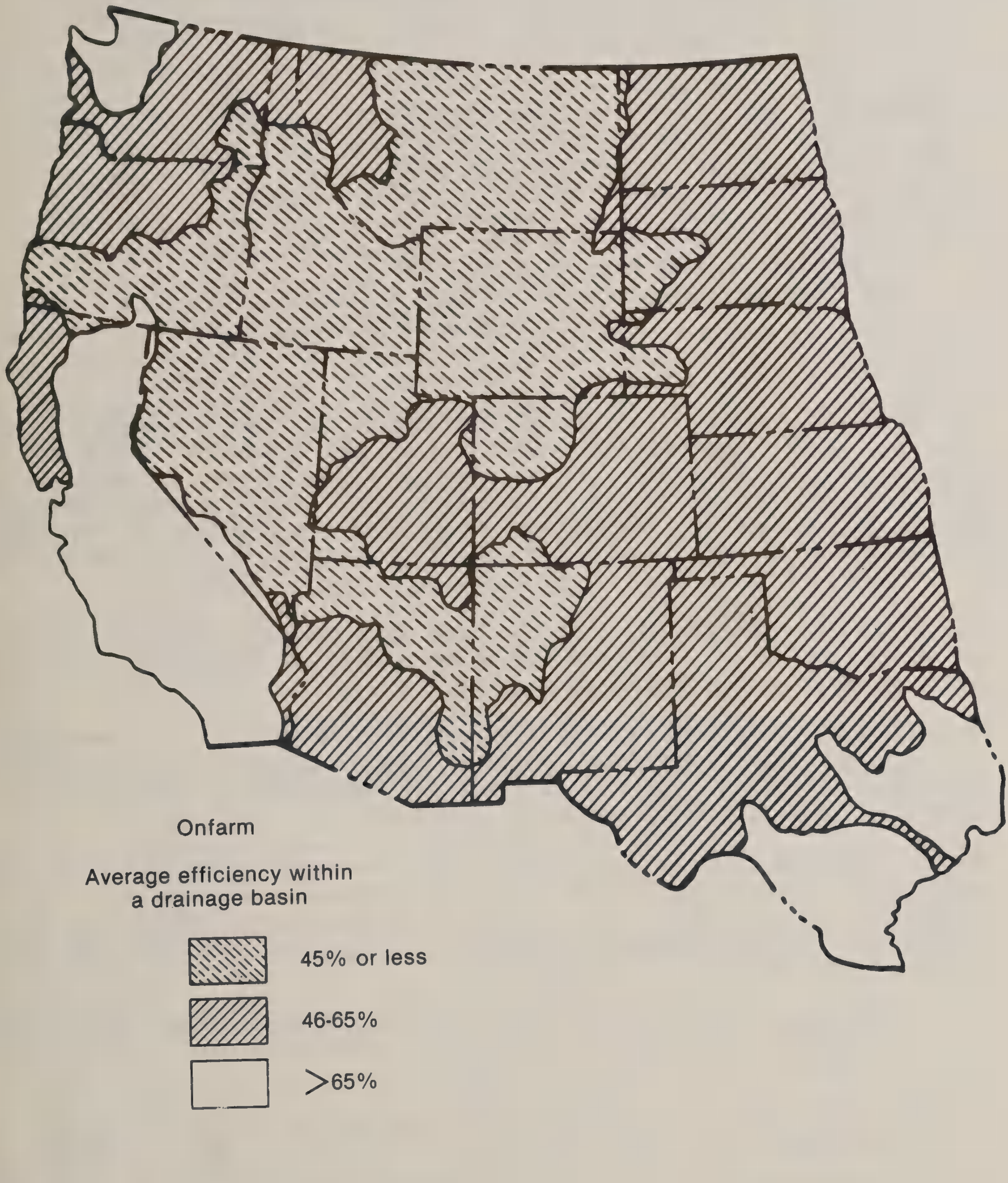


Figure 3C-15.--Onfarm efficiencies. (USDI et al., 1979)

Table 3C-10.--Water budget for the Sevier River Basin, Utah

		(1,000 acre-feet)
Water supply to irrigated area		1,148
Consumptive use		1,103
Irrigated rotation cropland	511	
Irrigated meadow	54	
Nonirrigated meadow	263	
Domestic use	9	
Phreatophytes	158	
Evaporation from water surface	108	
Return flow		45

the 158,650 acre-feet (14.4 percent of supply) now used by phreatophytes could be saved. Improved irrigation systems and management would reduce return flow and phreatophyte use. Such action might, however, be detrimental to wildlife habitat and the trees and shrubs that provide esthetic benefits in an arid environment. Furthermore, the costs and benefits of improving irrigation methods would need to be carefully analyzed to determine if they were economically justified.

Improvement measures are available to treat both off-farm conveyance systems and onfarm problems. These measures can reduce inefficiencies that are caused by physical and management problems.

The measures to treat off-farm problems relate to the physical and management aspects of conveying water from a point of supply (diversion or reservoir) to individual irrigators. Additional labor can contribute to increased efficiency by providing better service to irrigators.

Physical measures that can improve efficiency are constructing conveyance and distribution linings, installing closed pipe systems, and consolidating or realigning systems. Replacing or installing regulation structures, maintaining the system, and controlling aquatic or ditchbank weeds are some other physical measures.

- Linings will reduce seepage from canals and laterals and effectively improve water distribution and management. Linings are impervious materials installed within the perimeter of a waterway.

- Piped conveyance systems effectively improve irrigation operations and water use. They completely enclose the system to avoid many of the physical losses of water occurring in an open system. They are used where such physical barriers as steep escarpments and canyons make open systems impractical. Planners today usually consider piping conveyance and distribution systems in the early planning stages. In mountain valley situations, consideration should be given to installing pipelines for gravity sprinkler systems.

- <u>Consolidation or realignment</u> is possible today because of modern construction methods. Better irrigation system features such as improved water control structures and lining and piping materials make consolidation or realignment practical as effective water measures to conserve water.

- <u>Inline structures</u> include structures to measure and regulate water. Regulating devices are checks, checkdrops, turnouts, diversion structures, check inlets, control inlets, and regulating reservoirs. These structures are used to regulate the flow passing through the conveyance system and/or control the elevation of the upstream water surface.

  Accurate water measurement is important in operating any water conveyance system. Even for irrigation projects with surplus water, measuring devices are essential to keep an accurate account of what happens to the water. A proper evaluation of losses is needed to establish whether canal linings are economically advisable.

  Automated regulating structures increase the overall efficiency of the system and reduce operational waste. While storage reservoirs and the outlet works of dams, diversion dams, and canal headworks are often self-contained and isolated, they can be the focal point for demands on the conveyance system.

- <u>A weed control program</u> that can effectively minimize excessive vegetation in and along ditchbanks can be accomplished by mechanical, chemical, or biological means. Any method of control will have economic and environmental effects.

- <u>Scheduling water deliveries</u> is an important water management measure. Scheduling deliveries can allocate water in accordance with actual and projected crop use, rainfall, cultural practices, delivery system carrying capacity, and field irrigation characteristics.

Onfarm irrigation management determines the rate, amount, and timing of water application to ensure efficiency. Onfarm measures are used to counter irrigation inefficiency on the farm. These measures deal with the onfarm delivery system, field application system, and water management problems. Each measure has some degree of effectiveness in each irrigation situation.

- <u>Lining</u> ditches with concrete, asphalt, or other impervious material, or replacing them with pipelines is an effective method of reducing seepage.

- <u>Land leveling</u> is reshaping the surface of a field to planned irrigation grades or slopes and is most important in surface systems. Using land grades suitable for the field application system used allows better control and more uniform application of water, which may result in increased efficiency.

- Water control structures are those onfarm facilities that control and regulate the flow of water from the farm delivery point to the field.

- An automated irrigation system is a farm delivery system equipped with gates or valves, controlled by a sequencing timer alone or a timer plus soil moisture sensors. The main purposes for using automated systems are to reduce labor requirements and improve efficiency.

- Flow measurement devices allow the irrigator to apply the specified amount of water at each irrigation.

- Tailwater recovery systems are used to catch runoff created by irrigation and return the water to the original delivery system or divert it to another irrigated field.

- There are three methods for applying water--surface, sprinkler, and drip. Switching irrigation methods can often provide better control of the water supply.

Irrigators can often combine off-farm and onfarm measures to achieve the best overall water management. An example of this is the gravity pressured sprinkler system used in Star Valley, Wyoming. Gravity pipelines were installed during 1971-75 at a cost of nearly $300 per acre. The irrigators then installed sprinkler irrigation systems. The new system improved conveyance efficiency from about 60 percent to nearly 100 percent, and improved farm irrigation efficiency from approximately 15 percent to about 65 percent. This improvement in overall irrigation delivery and field efficiency reduced withdrawal of stream water considerably. Local streamflow now provides a full supply of irrigation water 96 percent of the time. A minimum flow of 6.4 cubic feet per second can now be maintained in Cottonwood Creek below the diversion, allowing some water to flow through 4 miles of channel that was previously dry part of the year. Reduced erosion and decreased leaching of crop nutrients have improved water quality (USDI et al., 1979).

The kinds and amounts of measures for solving irrigation problems vary considerably from area to area. In all 17 western states, irrigation water management, including scheduling, is an important nonstructural measure. Better onfarm management would improve irrigation on 28.4 million acres (table 3C-11). Facilitating better management, changing the method of irrigation on 3.5 million acres, and upgrading systems now in use would require such costly measures as control structures and ditch lining. Automation is needed on 20.6 million acres, tailwater recovery systems on 15.8 million acres, and land leveling on 11.6 million acres. Consolidation, realignment, and enlargement of conveyance systems, and lining or piping and control structures are off-farm measures needed in conjunction with onfarm measures.

Applying and installing measures that would help solve irrigation problems would have definite effects on water conservation, irrigation efficiencies, the environment, and the economic and social structure of the West. The implementation of measures outlined in table 3C-11 (USDI et al., 1979) could significantly change the hydrology in some basins. Changes in instream flow, wildlife habitat, and water quality would be expected. Onsite benefits often

Table 3C-11.--Measures and costs for irrigation characterization areas in the 17 western states (USDI et al., 1979)

Measure	Units (1,000)	Northwest		Southwest		Intermountain		Rocky Mountain		Northern Great Plains		Southern Great Plains		17 Western States	
		Quantity	Total cost[1] $ million	Quantity	Total cost[1] $ million	Quantity	Total cost[1] $ million	Quantity	Total cost[1] $ million	Quantity	Total cost[1] $ million	Quantity	Total cost[1] $ million	Total quantity	Total cost[1] $ million
Off-farm															
Consolidation, realignment & enlargement	feet	5,951.2	100.8	5,766.1	668.9	3,116.4	12.4	18,109.5	60.7	8,391.8	22.7	1,188.3	2.0	42,522.9	867.5
Lining & piping	feet	22,858.1	942.9	34,769.1	2,007.9	8,260.5	165.4	39,397.0	1,078.3	48,974.0	665.1	5,815.7	207.2	160,074.4	5,066.8
Control structures	each	23.1	81.2	4.1	8.0	5.9	20.5	42.8	123.1	10.6	41.7	6.8	5.1	93.3	279.6
Subtotal			1,124.9		2,684.4		198.3		1,262.1		729.5		214.3		6,213.9
Onfarm															
Lining & piping	feet	43,390.9	137.1	182,716.8	871.6	25,984.1	152.0	49,449.2	252.7	64,866.8	230.3	111,295.2	374.0	477,703.0	2,017.7
Land leveling	acres	338.9	50.9	4,534.9	678.3	487.7	54.0	558.3	90.0	1,458.1	260.0	4,238.6	813.0	11,616.5	1,946.2
Control structures	each	134.7	39.6	4,547.4	452.8	121.4	10.4	176.5	38.1	403.5	121.2	82.8	33.8	5,466.3	695.9
Change of method	acres	1,110.2	419.5	177.7	53.0	610.4	162.1	989.8	272.2	404.4	116.3	227.2	47.4	3,519.7	1,070.5
Tailwater recovery	acres	963.4	49.1	6,873.8	333.9	72.7	4.6	56.7	3.3	2,854.3	156.8	4,932.5	201.7	15,753.4	749.4
Irrigation water management	acres	2,620.2	13.1[2]	8,888.9	44.4[2]	1,826.4	9.1[2]	3,186.8	15.9[2]	4,792.5	24.0[2]	7,103.3	35.5[2]	28,418.1	142.0[2]
Automation	acres	815.4	166.2	10,228.3	1,022.3	285.1	12.1	192.1	22.6	2,688.6	346.7	6,431.6	330.8	20,641.1	1,900.7
Subtotal			862.4		3,411.9		395.2		678.9		1,231.3		1,800.7		8,380.4
Total Cost			1,987.2		6,096.7		593.5		1,941.0		1,960.8		2,015.0		14,594.3

[1] This is a one-time cost. 1977 price base.
[2] This is an annual recurring cost and not included in the subtotal and total costs.

do not justify extensive water conservation programs. However, offsite benefits, water quality improvement, addition to instream flows, and allocation of salvaged water make the measures in table 3C-11 feasible. Installing those measures would have the environmental effects summarized in table 3C-12 (USDI et al., 1979). Table 3C-13 shows the effects by characterization areas (USDI et al., 1979).

Suppressing Evaporation from Reservoirs.--Evaporation exceeds precipitation on 7 million acres of reservoir surface in the water-short areas. The average annual evaporation in the 17 western states ranges from 24 to 84 inches and is several times the annual precipitation in many areas. The net evaporative loss is 14 million acre-feet per year.

Various types of floating reflective covers are effective in reducing evaporation from small stock tanks. Locating new reservoirs at high altitudes and designing impoundments with deep water would result in cooler stored water, thus reducing evaporation from the water surfaces.

Stored Water Supplies.--Control of water supplies involves surface or ground storage. Water can be stored during wet periods and released to augment flows during dry periods or periods of large withdrawals (fig. 3C-16).

In many areas, there is a disparity between the patterns of seasonal water supply and water demands. Variations of this condition range from extreme flow fluctuations to high peak (e.g., power generation) or seasonal demands (e.g., irrigation). The disparities cause periods of water deficits (fig. 3C-17) in relation to needs for crops.

Water volumes and potential supplies can be measured at the stream outflow points. Of the 99 subregions in the conterminous United States, 68 subregions have average flows in 1 year out of 5 that are less than 80 percent of the mean annual yield. Although the other 31 subregions have flows greater than 80 percent of the mean annual yield in 4 years out of 5, they have many low monthly flows. These flows could be augmented by releasing water from storage.

Although storage cannot increase total supply, it can increase dependability. Dependable supplies are the quantities of water that can be relied upon for a specified amount of time. They are the volumes of both the water depleted for functional uses and the remaining streamflows, with a stated chance of shortage. Depletions are considered already obligated supplies. The streamflows are considered available supplies for withdrawal or instream uses.

The upper limit of supply (maximum draft) is the hydrologic mean yield. Storage capacity to completely regulate the streamflow (available supply) is impractical; 80 percent of mean annual flow is considered a possible practical development (practical draft).

Quantities of water must be available all the time for some uses, such as drinking water. A full supply 8 years out of 10 may be sufficient for an irrigator; a 20 percent chance of shortage can usually be tolerated by agriculture. In this report, the current available dependable supply is the

Table 3C-12.--Environmental impacts implementing water conservation measures on irrigation systems (generally considered as positive effects unless denoted by a minus sign) (USDI et al., 1979)

	Intermountain			Southwest			Northwest			Southern Great Plains		Northern Great Plains		Rocky Mountain	
	Mountain meadow	Intermediate valley	Lower valley	Mountain meadow	Intermediate valley	Lower valley	Mountain meadow	Intermediate valley	Lower valley	Intermediate valley	Onfarm	Intermediate valley	Onfarm	Mountain meadow	Intermediate valley
Water quality change - Surface															
salinity of return flow reduced,	0	L	X	0	L	X	0	L	X	L	X	L	L	0	L
Sedimentation reduced,	0	X	X	0	X	X	0	L	L	X	X	X	L	0	L
Pesticide residues reduced,	0	L	X	0	X	X	0	X	X	L	L	L	L	0	L
Nutrients reduced	0	L	X	0	X	X	0	X	X	X	X	X	X	0	L
Available water supply															
Instream flows[1]															
Irrigation season	L	X	X	L	X	X	L	X	X	X	L-	X	L-	L	X
Post-irrigation season	L-	L-	X	L-	L-	X	L-	X	X	X	X	X	X	L-	X
Ground-water aquifer															
Recharge reduced	L	L	L	L	X	X	L	X	X	0	0	0	0	L	X
Relief of depression cones	0	L	L	0	L	L	0	L	L	L	0	L	0	0	0
Fish and wildlife habitat															
Wildlife resource	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Resident fish	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Anadromous fish	0	0	0	L	L	L	X	X	X	0	0	0	0	0	0
Estuaries	0	0	0	D	L	L	D	L	L	L	D	D	0	D	D

[1] Assumes water made available is allocated to instream use to the extent needed.

X = Uniform
L = Local
0 = No Impact
D = Distant
- = negative impact

Table 3C-13.--Impacts by irrigation characterization areas (USDI et al., 1979)

Northwest Area

Type of Impact	Onfarm	Off-farm	Total
	(million acre-feet)		
Water budget			
Reduction in diversions	4.9	8.1	13.0
Reduction in incidental uses	0.3	0.5	0.8
Reduction in return flow	5.6	7.6	13.2
Increase in crop use	1.0	—	1.0
Improvement in efficiencies (percent)	19	15	

Environment

— Increased flow below mountain meadow areas in spring and summer, but reduced instream flow later in season.

— Reduction in diverted water would increase spawning areas and leave more water instream for fisheries through and below intermediate valleys.

— Decrease in the loss of anadromous fish fry from "wild flooding" of meadows.

— The effect on estuaries would be positive due to more freshwater inflow.

— Less total nutrient load and sediment in return flows would improve water quality.

— Some loss in wildlife habitat in intermediate valley irrigated areas.

— Improved aesthetic value at Shoshone Falls on the Snake River.

Economic/Social

— Cost of program — $2.0 billion.

Onsite

— Increase in net value of farm output is estimated to be $80 million annually.

— Decreased O&M of irrigation systems.

— Estimated overall reduction in energy requirement of about $18 million.

— Improved water supply in water-short areas.

Offsite

— Employment benefits resulting from program construction of about $10 million annually.

— Increased power production with greater streamflow.

— Improvement in navigation.

— Improvement in the commercial and sport fisheries for Pacific salmon.

— Employment resulting from program construction of 29,000 person-years.

— The increased agricultural income would generate an additional $90 million increase in regional income.

Other

— Increased storage needed in some areas, but less demand on some existing storage.

— Reduced ground-water recharge.

— Effect on some water rights.

Table 3C-13.--Impacts by irrigation characterization areas (USDI et al., 1979)--Continued

Southwest Area

Type of Impact	Onfarm	Off-farm	Total
	(million acre-feet)		
Water budget			
Reduction in diversions	6.7	4.3	11.0
Reduction in incidental uses	2.0	1.2	3.2[1]
Reduction in return flow	4.8	3.1	7.9
Increase in crop use	0.1	—	0.1
Improvement in efficiencies (percent)	12	7	

Environment

— Reduced diversions would improve fresh-water inflow to estuaries.

— General wildlife habitat reduction in irrigated areas.

— Improved aesthetic value of water resources.

— Improvement in water quality affected by nutrients and salts.

— Increased instream flows would benefit anadromous and other fish.

— Reduced salinity loading in the Colorado River.

Economic/Social

— Cost of program — $6.1 billion, one-time installation cost.

Onsite

— Estimated savings in energy use at about $40 million annually.

— Increase in net value of farm output is estimated to be $200 million annually.

— Improved water supply in water-short areas.

— Decreased O&M of irrigation systems.

Offsite

— A measure of the economic value of saved water of about $180 million annually.

— Salinity benefits at about $100 million annually.

— Reduced subsidence caused by pumping if conservation results in less ground-water overdraft.

— Employment benefit as result of the construction program of about $30 million annually.

— Reduced saltwater intrusion.

— Extended life of ground-water aquifer valued at about $15 million annually.

— Increase regional income of about $220 million generated from increased agricultural income.

— Employment resulting from program construction of about 90,000 person-years.

— Improvement of commercial and sport fisheries in the San Francisco Bay and of the coast.

Other

— Make possible better balance between surface and ground-water use.

— Possible impact on some downstream water users: (a) adverse change in flow patterns where storage is not available; (b) improved water quality.

— Decreased ground-water recharge in some areas.

[1] A more recent study in California (*Water Conservation in California*, May 1976, Bulletin No. 198) indicates that the sum of potential basin-wide water savings, excluding the Tulare Basin, is 1.17 million acre-feet per year, much of which is reused in the Sacramento-San Joaquin River Delta. Thus, only a minor portion would be available for other uses. The amount available could be as low as 540,000 acre-feet per year.

Table 3C-13.--Impacts by irrigation characterization areas (USDI et al., 1979)--Continued

Intermountain Area

Type of Impact	Onfarm	Off-farm	Total
	(million acre-feet)		
Water budget			
Reduction in diversions	-0.1	0.4	0.3
Reduction in incidental uses	0.1	0.1	0.2
Reduction in return flow	0.5	0.3	0.8
Increase in crop use	0.7	—	0.7
Improvement in efficiencies (percent)	10	5	

Environment

— Increase in early season instream flow below mountain meadows, but decrease in late season flows — less return flow entering terminal lake areas.

— Reduction in wildlife habitat associated with over-irrigation or seepage areas.

— Improvement of water quality — less leaching of salts and nutrients and less sediment from irrigated areas in intermediate valleys.

Economic/Social

— Cost of program — $590 million, one-time installation cost.

Onsite

— Decreased O&M of irrigation systems.

— Increase in quantity and quality of production, improving net farm income about $20 million annually.

— Decrease in energy for ground-water pumping — increase in energy due to system change to sprinklers.

Offsite

— Employment benefits resulting from program construction of about $3 million annually.

— Estimated salinity benefits of about $40 million annually.

— Employment resulting from construction program — 9,000 person-years.

— The increased agricultural income would generate an additional $20 million increase in regional income.

Other

— Extended ground-water supply (due to reduction in incidental use).

— Requires additional water storage.

— Possible impact on some downstream water users: (a) adverse change in flow patterns where storage is not available; (b) improved water quality.

Table 3C-13.--Impacts by irrigation characterization areas (USDI et al., 1979)--Continued

Rocky Mountain

Type of Impact	Onfarm	Off-farm	Total
	(million acre-feet)		
Water budget			
Reduction in diversions	0.3	3.2	3.5
Reduction in incidental uses	0.1	0.2	0.3
Reduction in return flow	1.2	3.0	4.2
Increase in crop use	1.0	—	1.0
Improvement in efficiencies (percent)	11	13	

Environment

— Increased streamflow in early season, but reduced streamflow in late season from mountain meadow.

— Adverse impact on wildlife habitat in intermediate valley irrigated areas and mountain meadows.

— Slight increase in water quality.

Economic/Social

— Cost of program — $1.9 billion, one-time installation cost.

Onsite

— Decreased O&M of irrigation systems.

— Improvement in economic base as crop production increases and is stabilized through firmed-up water supplies, valued at about $25 million annually.

— Savings in energy use of about $1 million annually.

— Improved water supply in water-short areas.

Offsite

— Increased chance of downstream spring flooding as less water is diverted in mountain meadow areas.

— Employment benefits from program construction of about $6 million annually.

— Some additional storage required.

— Salinity benefits will occur, but were not evaluated.

— Employment resulting from program construction of 28,000 person-years.

— Increase in agricultural income would generate $30 million of additional regional income.

Other

— Possible impact on some downstream water users: (a) adverse change in flow patterns where storage is not available; (b) improved water quality.

Table 3C-13.--Impacts by irrigation characterization areas (USDI et al., 1979)--Continued

Northern Great Plains

Type of Impact	Onfarm	Off-farm	Total
	(million acre-feet)		
Water budget			
Reduction in diversions	2.5	4.0	6.5
Reduction in incidental uses	0.4	0.6	1.0
Reduction in return flow	3.4	3.4	6.8
Increase in crop use	1.3	—	1.3
Improvement in efficiencies (percent)	16	14	

Environment

— Improved instream flow conditions between point of diversion and point of return flow.

— Assist in protection of vital habitat of the sandhill crane and the endangered whooping crane populations along the Platte River.

— Reduced fluctuation in instream flows.

— An opportunity exists for "saved" water in storage to be available for other uses such as instream flow, power, recreation, agriculture, and M&I.

— Reduced wildlife habitat in some irrigated areas.

— General improvement in water quality, including sediment, salinity, and pesticides.

Economic/Social

— Cost of program — $2.0 billion, one-time installation cost.

Onsite

— Increase in net value of farm output of about $130 million annually.

— Estimated saving in energy use of about $25 million annually.

— Decreased O&M of irrigation systems.

— Improved water supply in water-short areas.

Offsite

— Extend life of ground-water aquifers in general, but reduce ground-water recharge in some areas; is valued at about $8 million annually.

— Estimated employment benefits resulting from program construction of about $4 million annually.

— Employment resulting from construction program of 29,000 person-years.

— Increase in agricultural income would generate an additional $90 million increase in regional income.

Other

— Reduction in sprinkler evaporation losses.

— Possible impact on some downstream water users: (a) adverse change in flow patterns where storage is not available; (b) improved water quality.

Table 3C-13.--Impacts by irrigation characterization areas (USDI et al., 1979)--Continued

Southern Great Plains

Type of Impact	Onfarm	Off-farm	Total
	(million acre-feet)		
Water budget			
Reduction in diversions	3.3	1.0	4.3
Reduction in incidental uses	1.6	0.5	2.1
Reduction in return flow	1.9	0.5	2.4
Increase in crop use	0.2	—	0.2
Improvement in efficiencies (percent)	10	3	

Environment

— Improved instream flow conditions between point of diversion and point of return flow.

— Improved freshwater inflows to estuaries along Texas coast.

— An opportunity exists for "saved" water in storage to be available for other uses such as instream flow, power, recreation, agriculture, and M&I.

— Some wildlife habitat reduction in irrigated areas.

— General improvement in water quality with reduction in return flows.

— Potential for wildlife management at some playa lakes.

Economic/Social

— Cost of program — $2.0 billion, one-time installation cost.

Onsite

— Increase in net value of farm output of about $90 million annually.

— Reduced pumping cost and energy requirements of about $25 million annually.

— Decreased O&M of irrigation systems.

— Improved water supply in water-short areas.

Offsite

— Estimated employment benefits resulting from program construction of about $5 million annually.

— Extend life of ground-water aquifers, a value of about $30 million annually.

— A measure of the economic value of "saved" water valued at about $135 million annually (for agricultural use).

— Additional increase in regional income of $100 million annually generated by additional agricultural income.

— Employment resulting from construction program of 30,000 person-years.

— Gains from increased freshwater inflows to Galveston Bay and other estuaries could offset the other economic losses presently realized by the shrimp industry.

Other

— Reduced losses to non-recoverable ground-water aquifers.

— Some reduction in evaporation loss from sprinklers.

— Some reduction in storage needs.

— Possible impact on some downstream water users: (a) adverse change in flow patterns where storage is not available; (b) improved water quality.

Part A shows a hypothetical uncontrolled streamflow.

Part B shows the water from ground or surface storage released to augment low flows.

Part C shows the controlled flows that would result in the same stream with the storage and releases in part B. The releases increase the dependable supply available for offstream or instream uses.

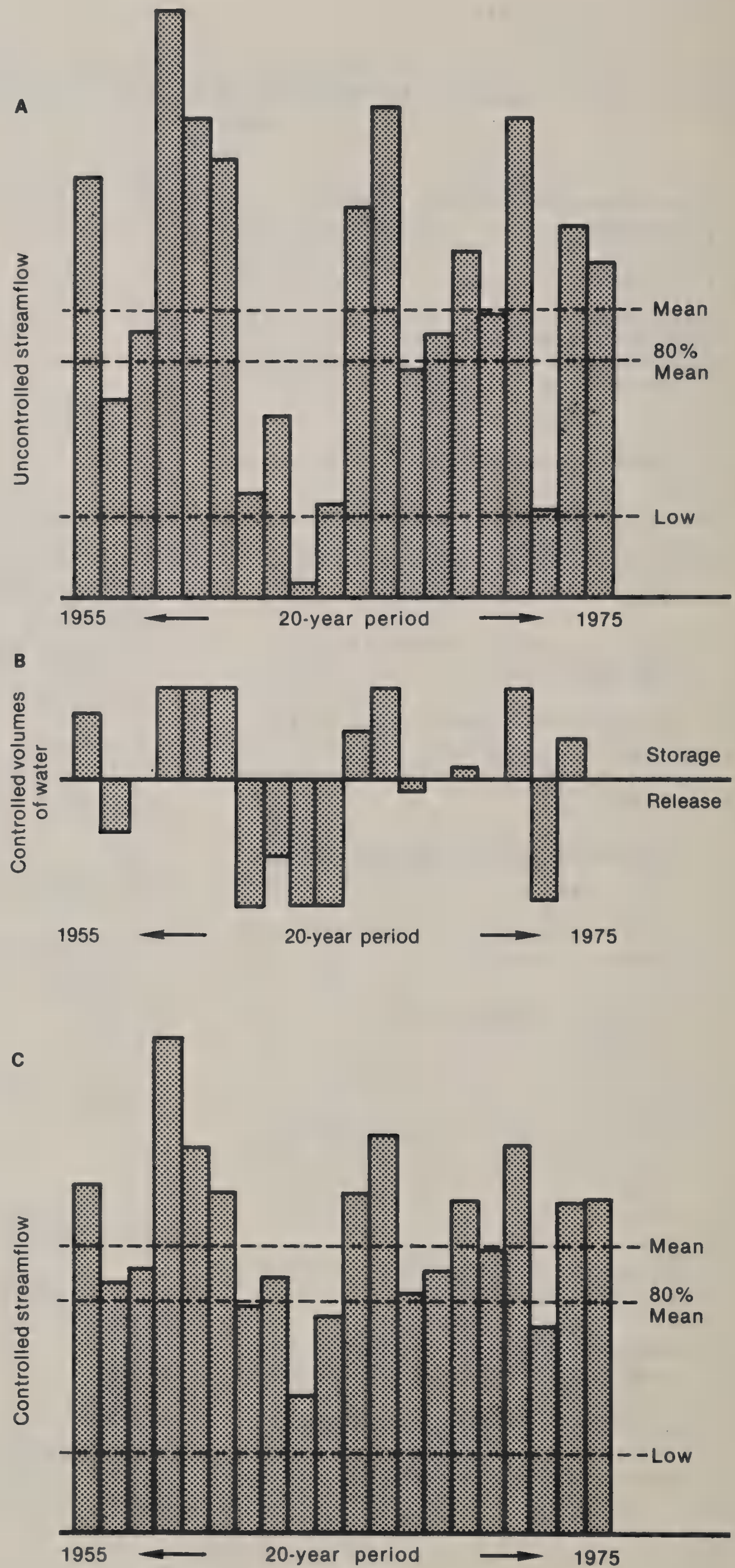


Figure 3C-16.--Hypothetical diagrams of the storage/release concept.

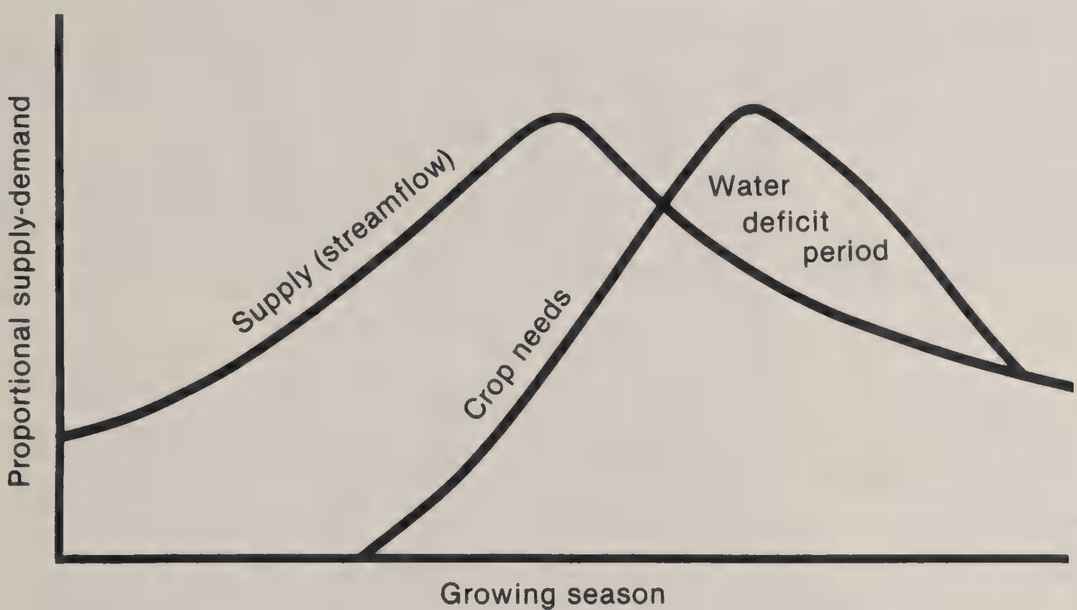


Figure 3C-17.--Seasonal water supply compared to crop needs.

present streamflow with a 20 percent chance of shortage. The potential available dependable supply is 80 percent of the mean annual flow with a 20 percent chance of shortage.

Determining the amount of storage required to obtain the potential available dependable supply requires an analysis of the flow regime. Plots of mass yield storage and storage release for various watersheds serve as the basis for the storage-yield relationships shown in table 3C-14. The storage required for a dependable supply depends on variations in runoff and streamflow (fig. 3C-18); the larger the variation, the larger the required storage.

A practical draft rate with 20 percent chance of shortage was selected to determine storage-yield relationships. For example, the mean annual yield from the Upper White Subregion (ASR 1101) is 15.9 bgd (17.8 million acre-feet per year). Variation in runoff in Missouri and Arkansas is medium. Sixty percent of the mean--10.7 million acre-feet storage--is required to meet the potential available dependable supply (an average 12.7 bgd for 4 years out of 5). The current streamflow is 10.5 bgd. In ASR 1101, releases from 10.7 million acre-feet of storage could augment low streamflows to increase the annual available dependable supply from 10.5 bgd to 12.7 bgd.

Table 3C-14.--Storage for practical draft (.8 mean annual yield)

Variation in runoff	Percentage chance of shortage 20	5
	(percentage of mean annual yield)	
Very low	20	
Low	40	85
Medium	60	110
High	80	150
Very high	100	

An estimated 833 million acre-feet of storage is required to realize the potential available dependable supply in the conterminous United States. If flows were to be controlled in only the 68 subregions needing year to year carryover, about 416 million acre-feet of storage would be required (table 3C-15). Only quantities of water yield and of draft rates were considered in determining required storage. Physical and economic feasibility were not used in the analysis to determine required storage.

If all the required storage were in surface reservoirs, 27 million acres of normal surface pool would be created in the conterminous United States. Evaporation would occur on these new water surfaces. Net evaporative losses

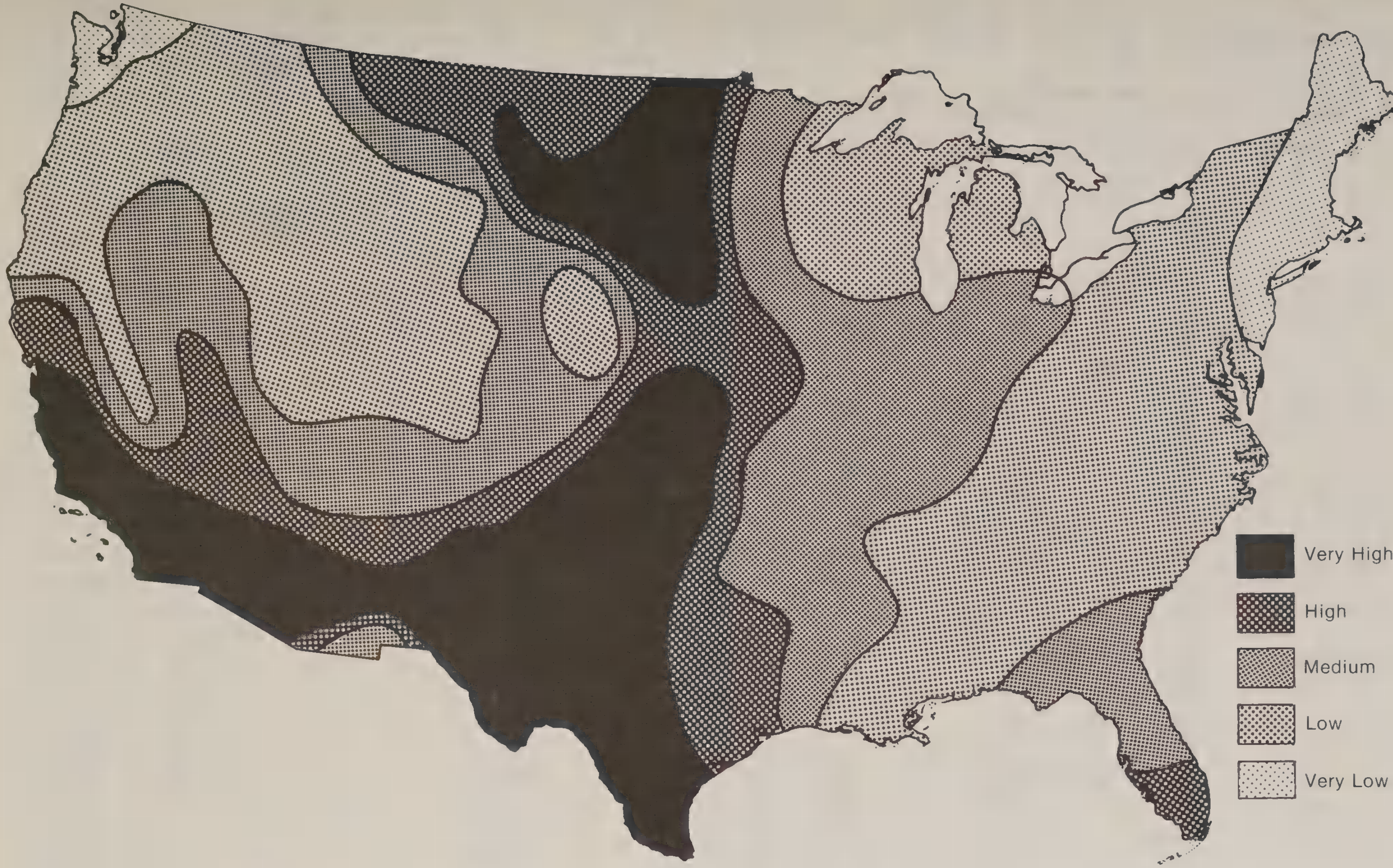


Figure 3C-18.--Variations in runoff. Source: U.S. Department of the Interior, Geological Survey. 1970. The national atlas of the United States of America.

Table 3C-15.--Storage required to meet potential available dependable supply

Water resources regions	Dependable annual streamflow: Current 1/	Dependable annual streamflow: Potential 2/	Storage required to meet potential: Additional volume	Storage required to meet potential: Surface area	Storage required to meet potential: Initial cost
	(billion gallons per day)		(mil. ac.-ft)	(thou. ac.)	(bil. 1978$)
New England------------	62.73	63.33	17.51	635	9.08
Mid-Atlantic-----------	70.41	73.49	22.98	547	17.21
South Atlantic-Gulf----	164.14	182.45	10.62	3,589	36.99
Great Lakes------------	57.28	57.28	34.21	1,342	22.29
Ohio-------------------	257.83	263.23	65.91	3,224	47.24
Tennessee--------------	55.20	55.20	18.28	787	9.14
Upper Mississippi------	198.40	210.50(-.18)	47.97	2,345	23.99
Lower Mississippi------	761.00	932.00	47.99	3,000	15.32
Souris-Red-Rainy-------	3.36	4.81	5.39	90	1.62
Missouri---------------	99.18	107.22(-2.00)	31.54	1,591	15.71
Arknasas-White-Red-----	42.49	58.31(-2.06)	44.31	2,179	18.77
Texas Gulf-------------	12.27	22.62(-1.49)	25.33	1,034	8.34
Rio Grande-------------	.90	2.06(- .16)	1.27	43	.51
Upper Colorado----------	13.12	14.75(- .42)	4.83	138	2.95
Lower Colorado----------	1.57	1.60(- .06)	.27	11	.29
Great Basin-------------	6.69	8.45(- .62)	5.61	220	8.27
Pacific Northwest-------	371.36	372.14(-2.34)	105.16	2,317	37.19
California--------------	30.43	38.62(- .27)	34.74	787	31.36
Cont. U.S.-all--------	2,208.36	2,468.06(-9.62)	622.92	23,897	30.627
Cont. U.S.-carryover ASRs 3/			416.45		198.30
Alaska------------------	795.00	795.00	202.76	3,379	405.52
Hawaii------------------	4.91	5.42	4.54	90	9.02
Caribbean---------------	3.30	3.88	3.26	82	3.26
United States & U.S. Caribbean--------	3011.57	3,260.26-9.62	833.48	27,448	724.10

1/ Current annual streamflows are sums of "dry year" outflows of the aggregated subregions (ASR's) from the Second National Water Assessment (NWA).

2/ Streamflow potentials are 80% of the sums of mean annual yields (outflows) of the ASR's from the NWA. The numbers in parentheses are the decrease in flows expected from net evaporative losses.

3/ Sixty-eight ASR's receiving less than 80% mean annual yield 2 years out of 10

range from zero in humid areas to 5 feet in some arid areas. The decrease in flows that might be expected from net evaporative losses is indicated as negative potential streamflow with storage in table 3C-15.

The initial cost of the additional storage in the 68 subregions is estimated at $198 billion (in 1975 dollars). Costs for the required storage are based upon initial installation (first-time) costs of floodwater retarding structures constructed as part of the watershed program (fig. 3C-19). If ground water recharge and storage were to prove less expensive than surface storage or if economies of scale could be realized, the required storage costs would be lower than those shown in table 3C-15.

o Surface storage.--Surface storage is an effective means of capturing and holding runoff water until it is needed for use during dry periods. Surface storage reservoirs are used to retain excess water that would otherwise be lost to the ocean during periods of above-normal runoff. In some arid and semiarid regions, reservoir storage capacity is such that little or no loss of floodwater occurs and irrigation can depend totally on runoff.

Total storage capacity of all surface reservoirs in the Nation is about 224.6 trillion gallons (700 million acre-feet). Of this total about 35 percent is used for flood control purposes and the remainder for water supply, hydropower, recreation, fire protection, and scenic purposes.

Surface storage areas are integral parts of distribution systems. They generally operate with gravity flow, and there are no energy costs for pumping. They require a minimum of operation and maintenance. They may provide for a number of incidental uses.

Surface storage has its greatest potential in the East, where the runoff tends to vary less and extremes are localized, and in areas where the average precipitation is adequate to meet requirements but deficiencies occur during dry periods. Within these regions, each reservoir site needs to be evaluated individually.

Locating storage reservoirs in upstream areas has a number of advantages. Some of these are:

- Landrights usually cost less.
- Water for beneficial uses is stored closer to the location of demand.
- The environment is enhanced by the distribution of water surfaces impounded behind upstream dams.
- Less water evaporates from high altitude headwaters.
- There is less disruption of transportation facilities, fish runs, utilities, and community life.

The development of additional sites for storage of surface water is expected to become less important because many convenient locations have already been

Figure 3C-19.--Initial installation costs of floodwater retarding structures (cost per acre-foot of storage capacity) in 1975 dollars.

developed; reservoirs have already been constructed in physically desirable sites; the cost of surface storage is becoming increasingly prohibitive; the evaporation losses from reservoirs in the subhumid, semiarid, and arid regions are large (15 bgd); and large capacity is required to increase the dependable supply. The physical and practical limits of potential surface storage development are not addressed in detail in this report.

o Ground water storage.--From 1900 to 1975, withdrawals of saline and fresh water increased at an average annual rate of 3 percent. During the last 25 years of this period, fresh surface water withdrawal increased at an annual rate of 2 percent, whereas fresh ground water withdrawal increased at a rate 3.8 percent--a significant increase in dependency on ground water for fresh water supplies.

Ground water is an effective water source for dealing with drought because there is little or no evaporative loss and weather fluctuations generally have little effect on ground water supplies. During years with subnormal precipitation, ground water provides much of the flow in many smaller streams in months of low flows. This is important to the continuity of streamflow.

Ground water in the United States is withdrawn at an average rate of 82 bgd. In 1975, ground water constituted over 40 percent of the total fresh water withdrawals, principally for irrigated agriculture (57 bgd).

A large number of aquifers, or reservoirs of ground water, are located within 2,500 feet of the Earth's surface. They are extensive and thick in some places, deep and thin in others. The runoff and seepage from rain and snow is enough to replenish some aquifers. For other aquifers, more ground water is withdrawn than can be replenished by runoff and seepage from rain and snow.

Recharge beyond what would naturally occur is practiced in some areas to take advantage of the ground water storage. Some water resource organizations inject water directly into the ground water aquifers. Others skim floodwaters into special recharge areas. Some deliver excess water to farmlands overlying gravelly ground water aquifers in upper reaches of river valleys. Others spread large quantities of water, far in excess of crop needs, on highly permeable soils that serve as principle recharge sites.

Most ground water recharge occurs on privately owned rural lands. Identification of areas underlain with significant aquifers, measures to improve percolation, delineation of recharge areas, and management of the ground water resource can lead to additional use of ground water storage.

Effects of Storage on Water Supplies.--In an average year, water supplies may be sufficient, but in a dry year supplies may be short. In 68 of the 99 subregions in the conterminous United States, releases from storage can significantly improve the dependable annual supply. The extent of improvement can be measured by comparing the ability of the current supply to meet demands with the ability of the potential supply (augmented with release from storage). Water budgets of several subregions illustrate storage potentials (table 3C-16).

Table 3C-16.--Water budgets, with and without storage, in dry years for selected subregions

Water data items by selected aggregated subregions (ASR)	1975 Normalized annual	1975 Normalized September	2000 without additional storage annual	2000 without additional storage September	2000 with potential storage annual	2000 with potential storage September
	(billion gallons per day)					
Southern Florida (ASR 305)						
Replenishable supply------	6.81	7.84	6.81	7.84	8.52 1/	12.77 1/
Ground water mining & imports---------------	.08	.05	0	0	0	0
Depletions---------------	2.75	1.95	3.78	2.75	3.78	2.75
Streamflow---------------	4.14	5.94	3.03	5.09	4.74	10.02
Instream flow req.--------	6.59	18.17	6.59	18.17	6.59	18.17
Surplus or deficit--------	-2.45	-12.23	-3.56	-13.08	-1.85	-8.15
% IFR and IDR 2/----------	63	33	55	31	77	57
Yellowstone (ASR 1004)						
Replenishable supply------	8.47	5.66	8.47	5.66	8.60 1/	7.45 1/
Ground water mining & imports---------------	.01	.01	0	0	0	0
Depletions---------------	2.40	3.02	3.51	5.24	3.51	5.24
Streamflow---------------	6.08	2.65	4.96	.41	5.09	2.21
Instream flow req.--------	7.36	4.51	7.36	4.51	7.36	4.51
Surplus or deficit--------	-1.28	-1.86	-2.40	-4.10	-2.27	-2.30
% IFR and IDR 2/----------	83	59	73	39	73	66
Upper-White (ASR 1101)						
Replenishable supply------	10.60	4.26	10.60	4.26	12.72 1/	4.68 1/
Ground water mining & imports---------------	.01	.01	0	0	0	0
Depletions---------------	.10	.07	.14	.10	.14	.10
Streamflow---------------	10.50	4.20	10.46	4.16	12.58	4.57
Instream flow req.--------	13.20	6.01	13.20	6.10	13.20	6.01
Surplus or deficit--------	-2.70	-1.81	-2.74	-1.94	-.62	-1.44
% IFR and IDR 2/----------	80	70	79	69	95	76

1/ Replenishable supply increased by release of stored water

2/ Percent of instream flow requirements (IFR) and increased depletion requirements (IDR) met by flow.

In Southern Florida (ASR 305) during an average year, 9.44 bgd replenish ground and surface supplies. Another 0.07 bgd in excess of recharge is pumped. Of water withdrawn from these supply sources, 2.20 bgd is consumptively used (depleted). That leaves a 7.31 bgd streamflow (available supply). Instream flow requirements of 6.59 bgd and increased depletions from 1975 to 2000 of 0.92 bgd are demands placed on the available supply. Thus, in an average year, a 0.20 bgd deficit exists. The water supply in an average year is capable of meeting 97 percent of instream flow and increased depletion requirements.

In the Southern Florida aggregated subregion (ASR 305) during a dry year (2 years out of 10), there is less water supply replenished and larger depletions; the streamflow (current dependable available supply) is 4.14 bgd. The 6.59 bgd instream flow requirements are demands placed on the limited amount of water--a 2.45 bgd deficit occurs. The current dependable available supply can meet 55 percent of instream flow and increased depletion requirements. The dependable available supply could be increased from 4.14 bgd to 5.85 bgd by releasing water from storage. The dependable available supply could then meet 77 percent of instream flow and increased depletion requirements.

Shortages are more extreme on a monthly basis than on an annual basis because of wider fluctuations in both supply and requirements. Consequently, a comparison of monthly supplies and requirements reveals the more critical water deficiencies. The extent of supply improvement with storage can then be more accurately assessed.

For example, the Yellowstone subregion (ASR 1004) has an average annual dependable available supply of 6.08 bgd and can meet 73 percent of instream flow and increased depletion requirements. But during a dry September the streamflow is only 2.65 bgd; it is then capable of meeting only 39 percent of the instream flow and increased depletion requirements. During September, 1.79 bgd released from storage could augment the flow to 4.44 bgd; the capability of water supply to meet requirements would then increase to 66 percent.

The ability of water supplies to meet requirements by month without and with developed potential storage has been tabulated for each of the humid subregions (table 3C-17). Only 6 of the 46 subregions in the humid area have water supplies sufficient to meet 70 percent of the increased depletions (to the year 2000) and instream flow requirements in a dry October. With storage, 41 of the 46 subregions would have available supplies to meet over 70 percent of October increased depletion and instream flow requirements. In the dry area, 30 of the 50 subregions will not have available supplies to meet even 30 percent of the increased depletions and instream flow requirements; with storage, this number could be reduced from 30 to less than 20 subregions.

Alternative Objective Levels

Population growth, industrial development, and changing water use priorities are placing new demands on our water resources. The result has been local water shortages and increased competition for limited supplies. Water resources are often limited or seriously polluted. Ways must be found to

Table 3C-17.--Ability of humid subregion water supplies to meet requirements without and with storage

Month	Number of subregions in which various levels (%) of instream flow and increased depletion requirements can be met by dependable available supply							
	Without storage				Potential with storage			
	90%	79-90%	30-70%	30%	90%	70-90%	30-70%	30%
January	-	7	37	2	7	38	1	--
February	-	19	26	1	6	38	2	--
March	3	23	19	1	4	41	1	--
April	4	18	23	1	5	40	1	--
May	3	15	27	1	4	41	1	--
June	1	13	31	1	9	36	1	--
July	-	9	35	2	4	41	1	--
August	-	11	33	2	5	35	6	--
September	-	9	36	1	8	33	5	--
October	-	6	40	-	9	32	5	--
November	-	10	35	1	7	34	5	--
December	-	6	39	1	12	31	3	--

augment the water supply and achieve the greatest use from existing resources.

We can achieve optimal use of our water resources by eliminating wasteful and unnecessary water use and by controlling existing water supplies more effectively. This includes reducing losses and waste, improving efficiency in use, modifying demand, and managing watershed runoff and streamflows.

The first step in setting objective levels is projecting the extent of future water supply problems. Figure 3C-20 shows the range in investments in water conservation and water supply that will be relevant in the future. Even to hold our own in the water supply area will require future investments. A portion of today's expenditures for soil and water conservation goes to maintaining and replacing existing facilities. Improvements are usually made and new technology is applied, and this increases the amount of water available. But to meet the greater needs of the future will require continued attention to maintaining existing facilities and to supplying additional amounts of water through conservation or supply development.

The following are the objective levels selected for analysis under RCA.

Level 1.--The goal would be a water conservation program for irrigated agriculture in water-short areas that is realistically achievable by 2010 using existing technology. Beyond that time, the water saved under this

program will be assumed to be one-half of that saved from 1975 to 2010. Savings would be achieved through new technology and greater acceptance of water conservation measures by irrigators. These savings are based on the assumption that water gained through increased storage will be available to meet all water demands. The demands of agricultural and nonagricultural users would receive equal priority. Shortages would be shared proportionately. The RCA analysis of this program will show effects on existing instream flow approximations.

Level 2.--The goal at this level would include the water conservation program in level 1. It would be modified to reflect the assumption that additional water supplies developed through storage or ground water withdrawal in water-short areas would be used only for nonagricultural purposes. The RCA analysis of this modified program would assume that the consumptive use demand for agriculture would have first call on water saved.

Level 3.--At this objective level, the water conservation program for 2030 would be applied uniformly. The RCA analysis of this program assumes that because of environmental concerns, additional water supply development would not be undertaken. Because agriculture can be outbid for available water, it is also assumed that all water savings would go first to meet nonagricultural consumptive use demands. This objective level is based on the assumption that a minimum level of water will be available for agriculture in future years. See figures 3C-21, 3C-22, and 3C-23.

Recommendations for Future Analysis

USDA should base future analyses of water supply and conservation on water accounting in smaller hydrologic areas, monitoring the effectiveness of current programs, collecting data on sample units, performing case studies, and new research findings. The physical limitations on storage need to be determined. USDA needs to more clearly identify onfarm versus off-farm irrigation opportunities and determine which irrigation systems are most cost effective. USDA needs to devise a program formulation process to mesh activity elements.

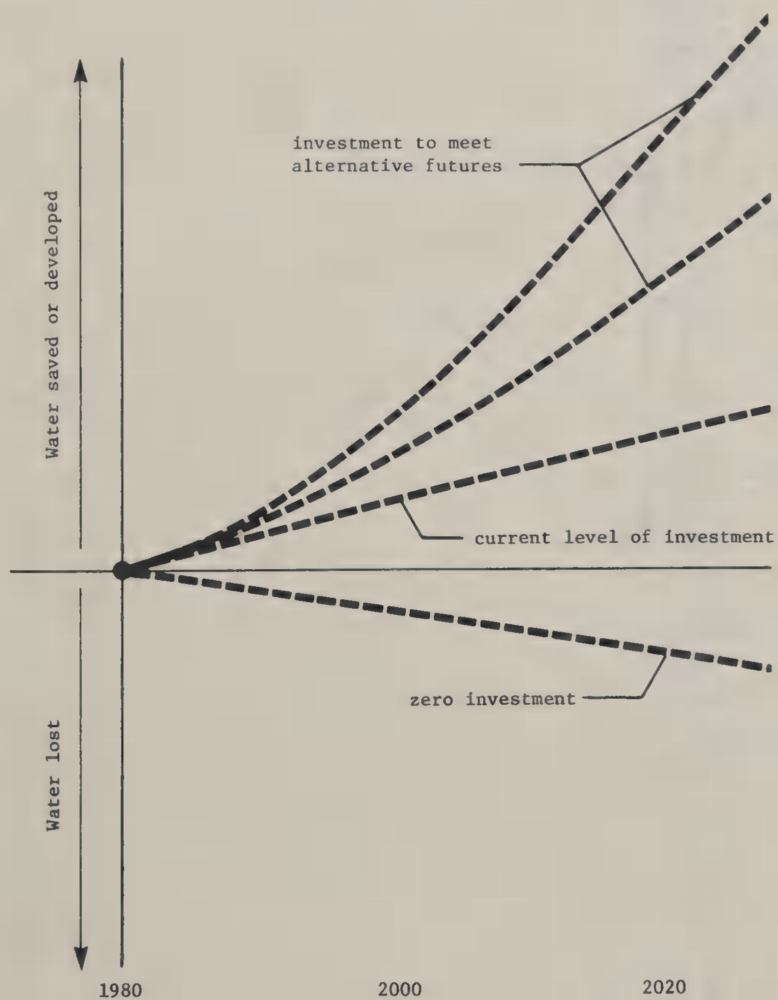


Figure 3C-20.--Range in total public and private future investments in water conservation and supply.

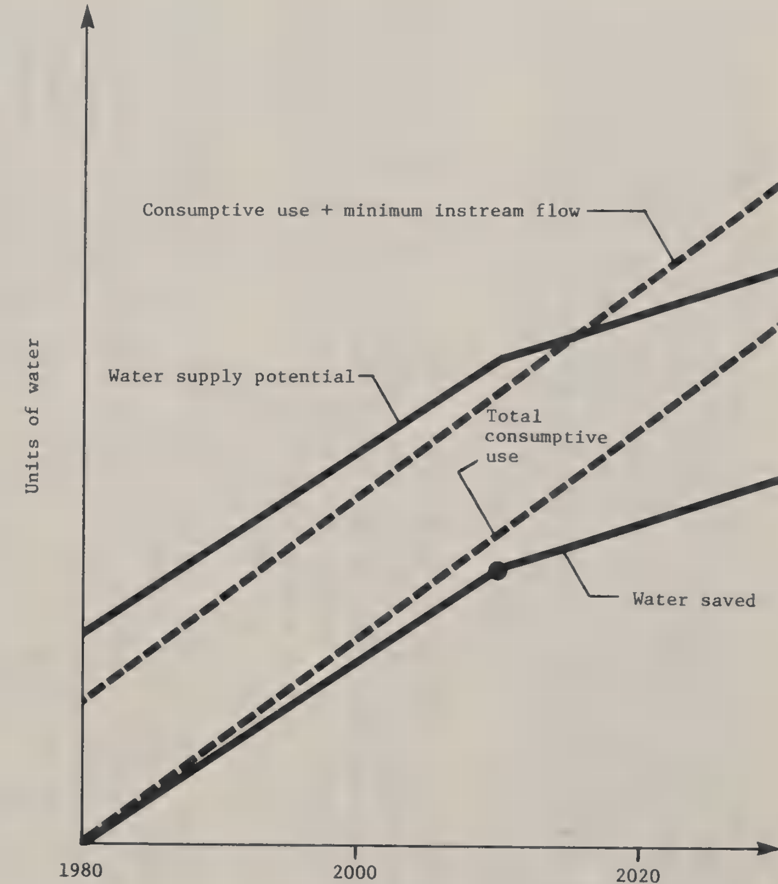


Figure 3C-21.--Water saved, developed, or used--objective level 1.

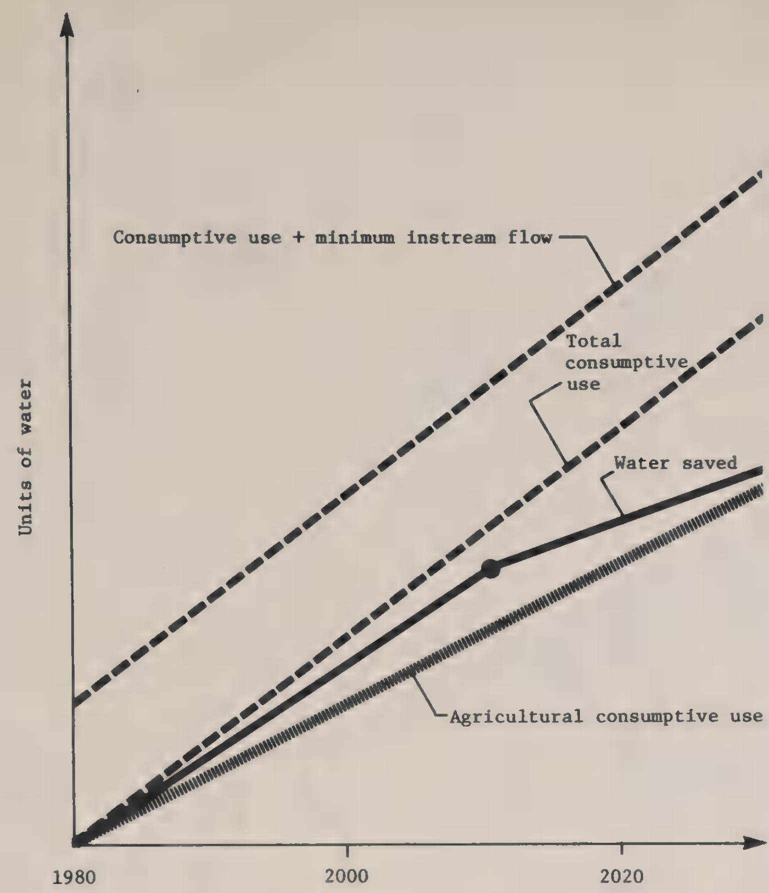


Figure 3C-22.--Water saved, developed, or used--objective level 2.

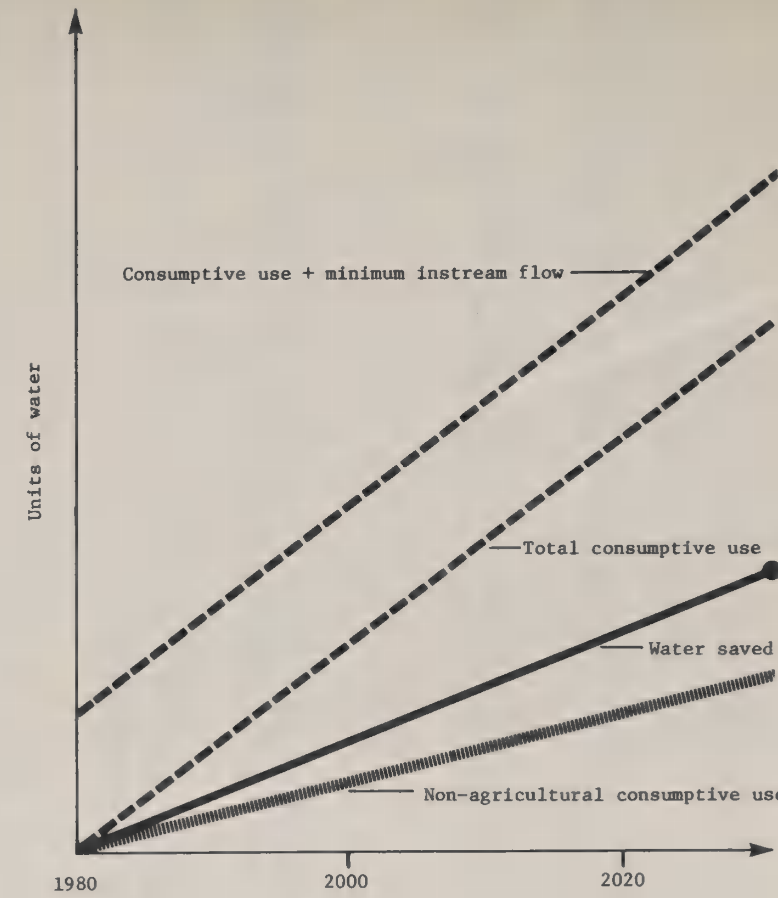


Figure 3C-23.--Water saved, developed, or used--objective level 3.

References

National Academy of Sciency. 1976. Climate and food.

National Water Commission. 1973. Water policies for the future: Final report to the President and Congress.

United States Department of Agriculture. 1977a. 1977 Handbook of agricultural charts. Agriculture Handbook No. 524.

United States Department of Agriculture. 1977b. Water conservation to minimize the effect of drought.

United States Department of Agriculture. 1977c. Agricultural resources assessment system, benchmark analysis and modified central case. Vol. 1.

United States Department of Agriculture, Soil Conservation Service. 1978. 1977 National resource inventories.

United States Department of Agriculture. 1979. Weather and water allocation study for the President and Congress.

United States Department of Commerce. 1974. 1974 Census of agriculture, irrigation and drainage on farms.

United States Department of the Interior, United States Department of Agriculture, and United States Environmental Protection Agency. 1979. Irrigation water use and management: An interagency task force report.

United States Environmental Protection Agency. 1979. Water supply-wastewater treatment coordination study.

United States Water Resources Council. 1978. The Nation's water resources 1975-2000--Second Natl. Water Assess. Vol. I: Summary.

Section D-Potential Problem Area 4, Fish and Wildlife Habitat

Completion of the 1980 RCA Appraisal required that terrestrial and aquatic wildlife habitat be evaluated and potential problems be identified. Because USDA collected no new data on wildlife habitat for the 1980 Appraisal, it analyzed available data. However, the data base that it used was not designed for identifying problems associated with wildlife habitat. Nor is there a generally accepted method for inventorying and evaluating fish and wildlife habitat. The federal agencies do not have a compatible approach to wildlife inventories, although efforts are underway to develop one (Hirsh, et al., 1979).

The system that was developed under these conditions provides the measure of wildlife habitat quality that it was designed to provide. However, the results must be interpreted in light of several caveats. First, the indices that this system produces indicate relative differences in wildlife habitat value, but do not show the absolute magnitude of the difference. For example, habitat with a diversity rating of 1.0 is "better" habitat for those species that require diversity than is habitat with a rating of 0.5, but it is not necessarily twice as good.

Second, only certain habitat elements were considered in the analysis. Because wildlife habitat quality may be influenced by factors which were not included in the analysis and which would vary in ways unrelated to the factors that were included, the results of the evaluation may be inaccurate.

Last, the diversity and quality factors which were included were intended to measure habitat suitability for a wide variety of vertebrate species, both game and nongame. The system does not adequately measure suitability of the habitat for any one species.

Problem Statement

All land has the potential or capability to produce and sustain wildlife. The primary land use limits the capability of the land to produce and sustain wildlife in a variety of ways, depending on use and management. Cropland provided habitat for a wide variety of wildlife species when farm holdings were small, crops were diversified, and hedgerows, fence rows, and vegetated streambanks were common. In recent years, however, as farms have increased in size and farmers have turned to monoculture and mechanization, the quality of wildlife habitat on cropland has declined.

Grazing of forest land also affects the quality of the wildlife habitat. Overgrazing reduces the value of the understory vegetation for cover. Livestock compete with wild animals for food, but the competition is least severe in well managed woodlands. Any grazing on hardwood forests, western riparian areas, and steep or rocky slopes is generally detrimental.

The quantity and quality of wildlife habitat on rangeland and native pasture depend on the primary land management system. Rangeland in poor condition provides poor habitat for most species of rangeland wildlife as well as low quality grazing for livestock. Livestock can trample or overgraze vegetation and compact the soil so that its ability to absorb water is reduced. Competition among animal species can seriously degrade wildlife habitat.

The large scale conversion of any habitat type to pastureland has negative effects on nearly all wildlife species. In large tracts of intensively managed pasture where one or two forage species are dominant, the value to wildlife is extremely small. The overall habitat value of pastureland depends on its quality and diversity. Overuse of pasture degrades the value of pasture as wildlife habitat.

In this survey, the land use categories recorded as pastureland were domestic pasture, rotation hay and pasture, hayland, and farmsteads. Native pasture was recorded as rangeland.

Wetlands have been drained and filled to create larger fields for monoculture, destroying large areas of wetland wildlife habitat. During the 1950's and 1960's, dredging and filling activities destroyed many acres of coastal habitat. Between 1954 and 1977, the average annual loss of wetlands was more than 500,000 acres. Table 3D-1 shows the acreage of wetlands in 1954 and in 1977. (Additional information is in the RCA Appraisal, Part I, chapter 6.)

Table 3D-1.--Wetland inventory data

Wetland types	1954 inventory (Shaw and Fredine, 1956)	1977 inventory (USDA, 1978)
1 and 2----------------	33.7	29.0 (Estimated)
3 to 20----------------	48.3	41.5
Total-------------	82.0	70.5

Problems related to fish habitat are associated with water quality and streamflow in rivers and streams, poor management of fish ponds, and technological and administrative problems that limit the conservation, development, and use of private lands and waters for aquaculture.

Scope

The primary source of data concerning wildlife habitat was the 1977 National Resource Inventories (NRI) (USDA, 1978). About 59,000 primary sample units (PSU) of about 160 acres each were used for these inventories. Each PSU had three primary sample points. USDA recorded the land use, conservation practices applied, conservation treatment needed, potential for flooding, type of wetland, and other data at each sample point. Conservation practices recorded were good woodland grazing management, brush management, tree planting, windbreaks, range seeding, grassed waterways, and contour stripcropping. Treatment needs recorded were protection from grazing, grassland improvement, brush control, and drainage needed. All of these data indicated the quality and diversity of the vegetation.

USDA used the following assumptions in identifying the scope of this problem:

1. The land's capability to produce and sustain wildlife is related to its potential plant community, the stage of succession of the plant community, and the kinds of plant communities on adjacent areas.

2. The inherent capability of the plant community to provide an element or elements of wildlife habitat is subject to limitations resulting from natural causes and human activities. These limitations can change the species composition and spatial arrangement of the plant community.

3. Various land uses, intensity of use, and management practices and technology may greatly alter or diminish the capability of plant communities to provide suitable habitat. Conversely, applying a set of practices may enhance the capability of land to provide habitat by overcoming or lessening the natural or man-caused limitations.

Wildlife Habitat Diversity.--From the land use recorded at each of the three sample points, USDA determined the diversity of the wildlife habitat on each sample unit (PSU). Diversity ratings were assigned to each PSU on the basis of the various combinations of land use at each of the three points.

For cropland the following diversity ratings were assigned:

(C = Cropland, P = Pastureland, F = Forest land, R = Rangeland, and O = Other land. These codes show land use at each of the three sample points in each sampling area)

CPR = 1.0	CCR = 0.6	CPO = 0.4
CPF = 1.0	CRR = 0.6	CRO = 0.4
CRF = 1.0	CCP = 0.6	CCC = 0.4
CCF = 0.8	CFO = 0.5	CPP = 0.3
CFF = 0.8	CCO = 0.4	COO = 0.2

Optimum rating = 1.0

Figure 3D-1 shows the average diversity ratings for habitat on cropland, by aggregated subarea (ASA). The optimum diversity value of 1.0 indicates that three different land uses occur on one primary sample unit; the more uniform the land use, the lower the rating. Problems with diversity are greater in ASA's where monoculture or large solid blocks of cropland, occurs.

For forest land the following diversity ratings were assigned:

CPF = 1.0	PFF = 0.9	PPF = 0.5
CRF = 1.0	CCF = 0.8	CFO = 0.5
PFR = 1.0	CFF = 0.8	RFO = 0.5
FFR = 0.9	FFF = 0.7	PFO = 0.4
FRR = 0.9	FFO = 0.6	FOO = 0.2

Optimum rating = 1.0

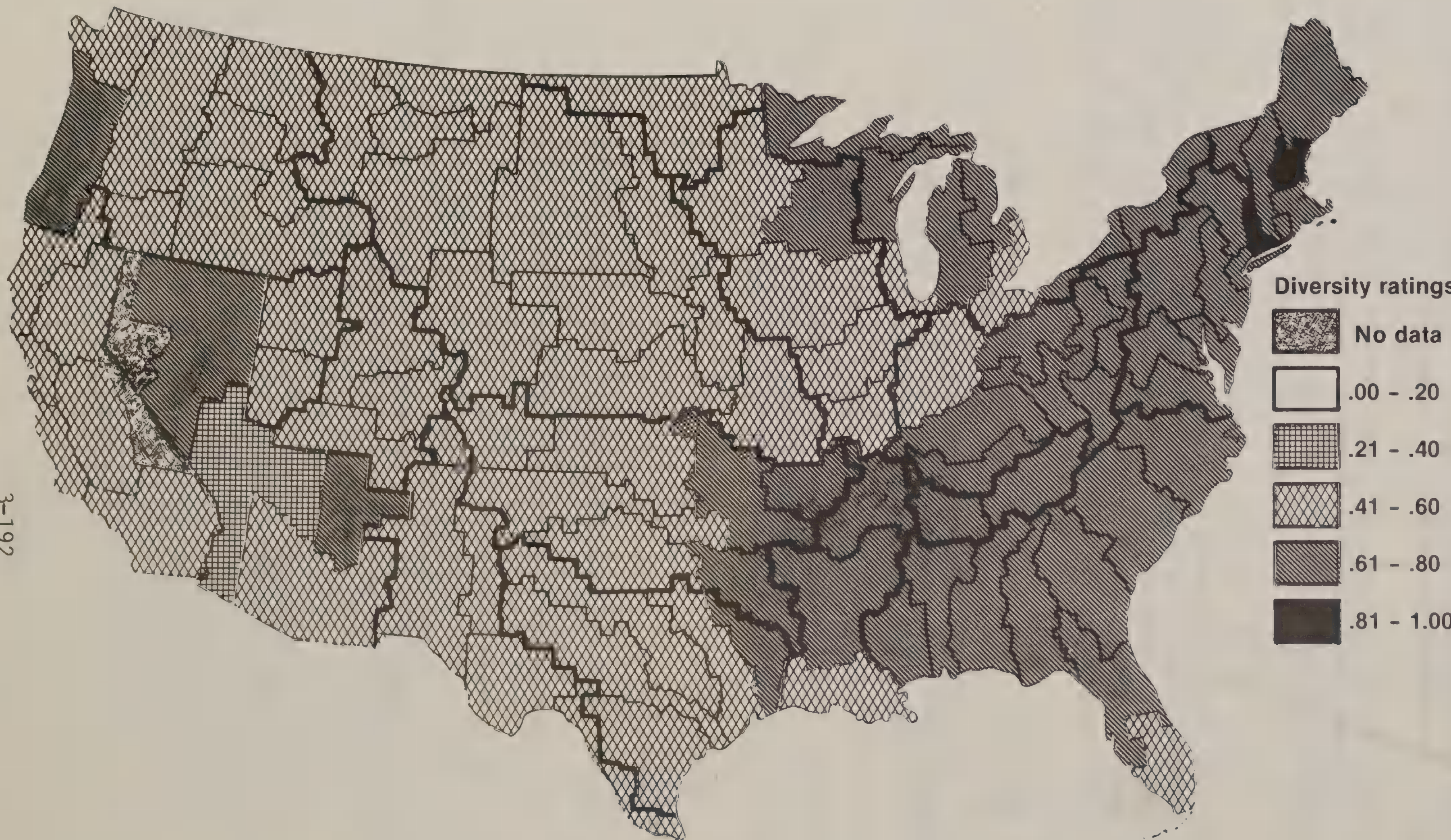


Figure 3D-1.--Diversity ratings for wildlife habitat on cropland, by ASA. (USDA, 1978)

Figure 3D-2 shows the average habitat diversity ratings for forest land, by ASA. Most forested areas have a diversity rating of more than 0.61. Highest values for forest land are in the Midwest. On areas where all sample points occur on forest land, the diversity value is 0.7. Diversity values on forest land are not a major problem.

For rangeland and native pasture the following diversity ratings were assigned:

CPR = 1.0	RRR = 0.7	RFO = 0.5
CRF = 1.0	PRR = 0.7	CRO = 0.4
PFR = 1.0	CRR = 0.6	PRO = 0.4
FFR = 0.9	CCR = 0.6	RRO = 0.4
FRR = 0.9	PPR = 0.5	ROO = 0.2

Optimum rating = 1.0

Diversity ratings for wildlife habitat on rangeland and native pasture are shown by ASA in figure 3D-3. ASA's with low diversity values for rangeland habitat are concentrated in the Great Plains, the West, and southern Florida. However, diversity values on rangeland are generally high and do not appear to constitute major problems.

For pastureland the following diversity ratings were assigned:

CPR = 1.0	CCP = 0.6	PFO = 0.4
PFR = 1.0	PPF = 0.5	PPO = 0.3
CPF = 1.0	PPR = 0.5	CPP = 0.3
PFF = 0.9	CPO = 0.4	PPP = 0.2
PRR = 0.7	PRO = 0.4	POO = 0.2

Optimum rating = 1.0

Wildlife Habitat Quality.--USDA also determined the quality of the habitat at each sample point, based on the availability and condition of food and cover as indicated by the available data. It assigned weighted values to each of the factors identified as important to a particular kind of habitat and then determined a standard value by adding the weighted values for all factors and practices. Finally, USDA obtained a quality rating by adding the weighted values for each factor present and dividing the sum by the standard value.

The quality ratings for wildlife habitat on cropland were based on the following assumptions:

1. Grain crops provide better habitat than nongrain crops.
2. Residue left on the soil surface improves the habitat.
3. Installed practices such as grassed waterways, windbreaks, and contour stripcropping improve the quality of the habitat to varying degrees.
4. Wet cropland or cropland needing drainage is better habitat for a wide variety of species than is drained cropland.

Factors that contribute to the quality of habitat on cropland were assigned the following weighted values:

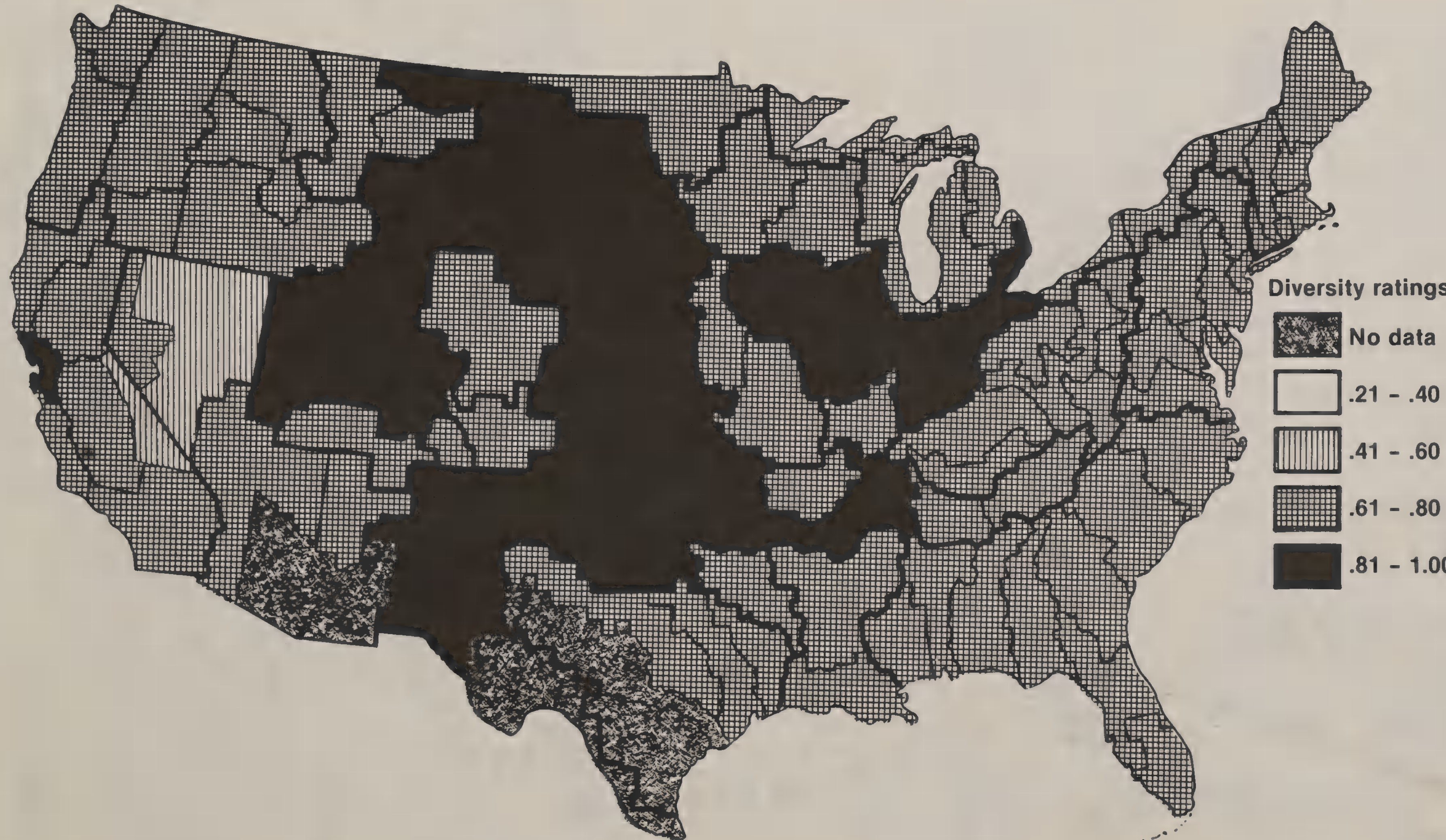


Figure 3D-2.--Diversity ratings for wildlife habitat on forest land, by ASA. (USDA, 1978)

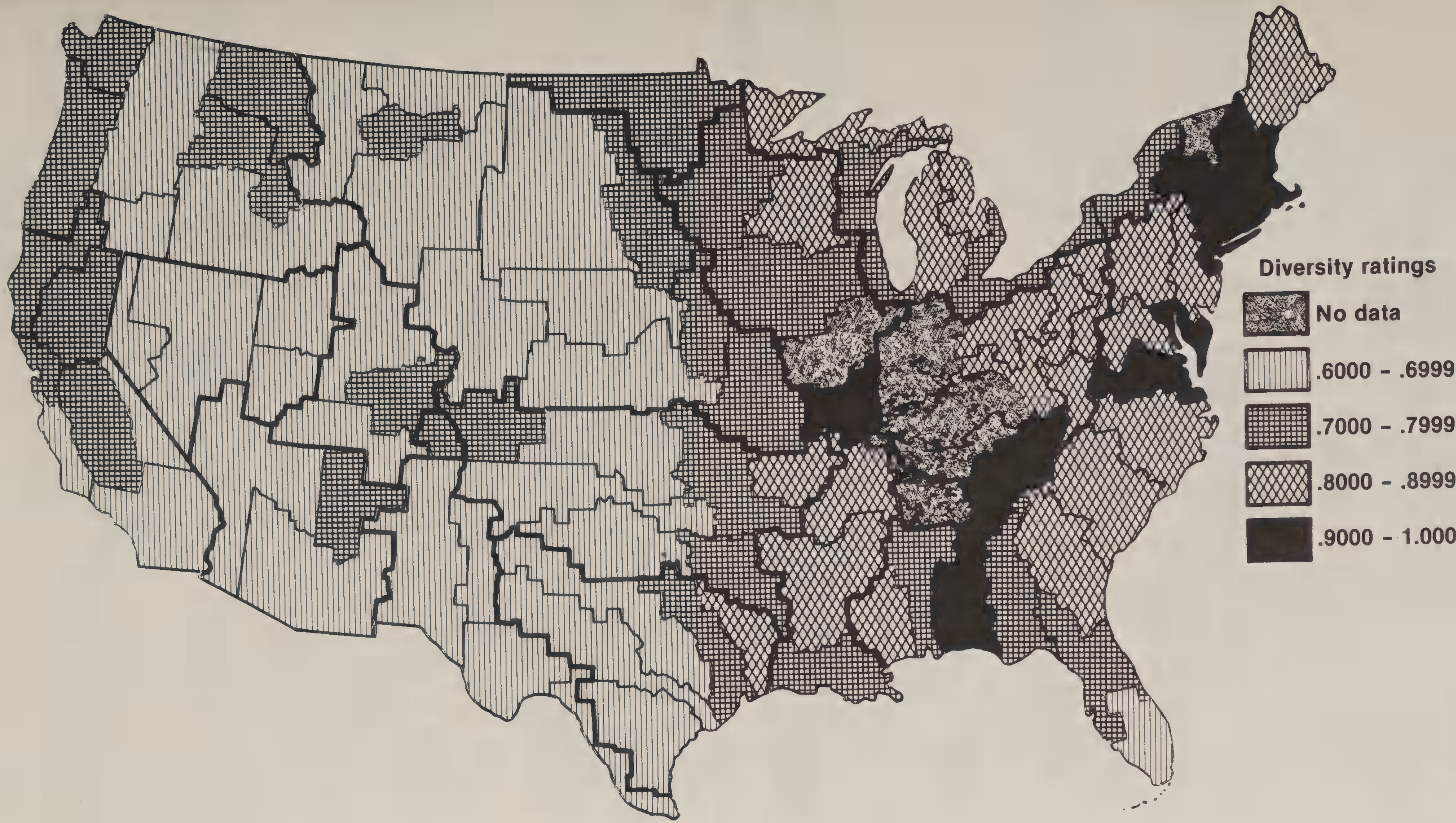


Figure 3D-3.--Diversity ratings for wildlife habitat on rangeland and native pasture, by ASA. (USDA, 1978)

Grain crop	= 4, or nongrain crop	= 1
Grain residue present	= 3, or nongrain residue present	= 1
Grassed waterway	= 1	
Windbreak	= 2	
Grain strip crop	= 3, or nongrain strip crop	= 1
Wetland	= 3	
	16 = standard value	

The standard value for determining habitat quality on cropland is 16. The quality rating is obtained by adding the weighted value for each factor that occurs in the unit and dividing by 16. If all factors or practices were present, the quality rating would be 1.0.

Figure 3D-4 shows the average quality rating for wildlife habitat on cropland, by ASA. Only nine ASA's had average habitat quality ratings of more than 0.48. Most ASA's are providing less than half of their potential for cropland wildlife habitat.

The quality ratings for wildlife habitat on forest land were based on the following assumptions:

1. Habitat quality is higher in ungrazed forests than in grazed forests.
2. Forests where grazing is well managed are better habitat than those where grazing is not well managed.
3. The canopy cover and understory cover, as expressed by the "C" factor of the universal soil loss equation (see chapter 7, section A), indicate quality.
4. The uniform stand density of planted forests provides less diversified, hence lower quality, habitat.
5. Wet or flooded forests are higher quality habitat than forests that are not wet.

Factors that affect the quality of wildlife habitat on forest land were assigned the following weighted values:

Ungrazed	= +5, or good grazing management = +3
"C" value	= +4, 3, 2, or 1 (4 = 45-75 percent canopy, 3 = 76-100 percent canopy, 2 = 20-44 percent canopy, and 1 = less than 20 percent canopy.)
Tree planting	=-1
Wetland or flooding	=+2
	11 = standard value

Figure 3D-5 shows the average quality rating for wildlife habitat on forest land, by ASA. The highest quality ratings occur in the Southeast, Northeast, Upper Midwest, and Lake States. The lowest ratings occur in ASA's west of the Mississippi.

The quality ratings for wildlife habitat on rangeland and native pasture were based on the following assumptions:

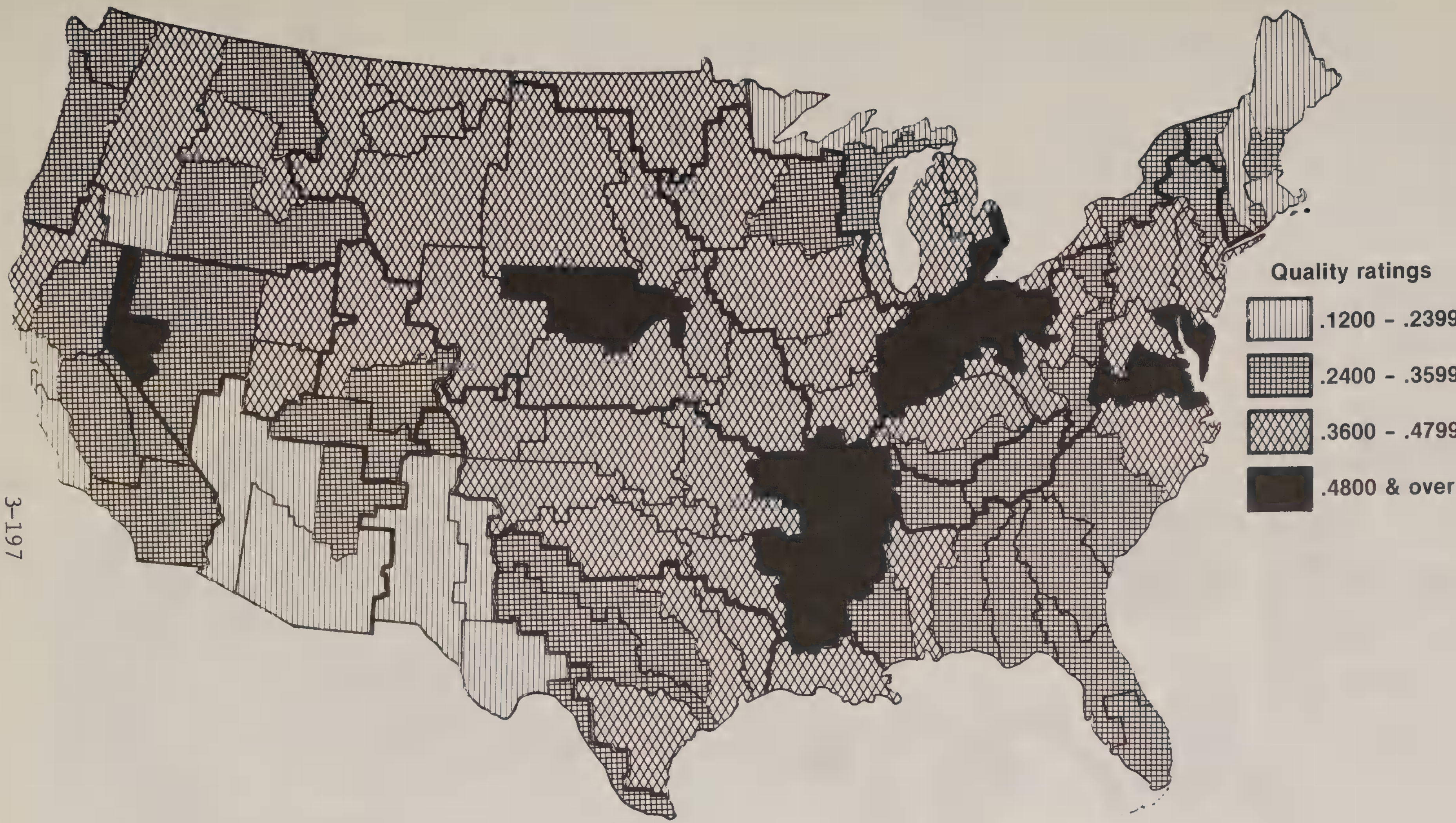


Figure 3D-4.--Average quality ratings for wildlife habitat on cropland, by ASA. (USDA, 1978)

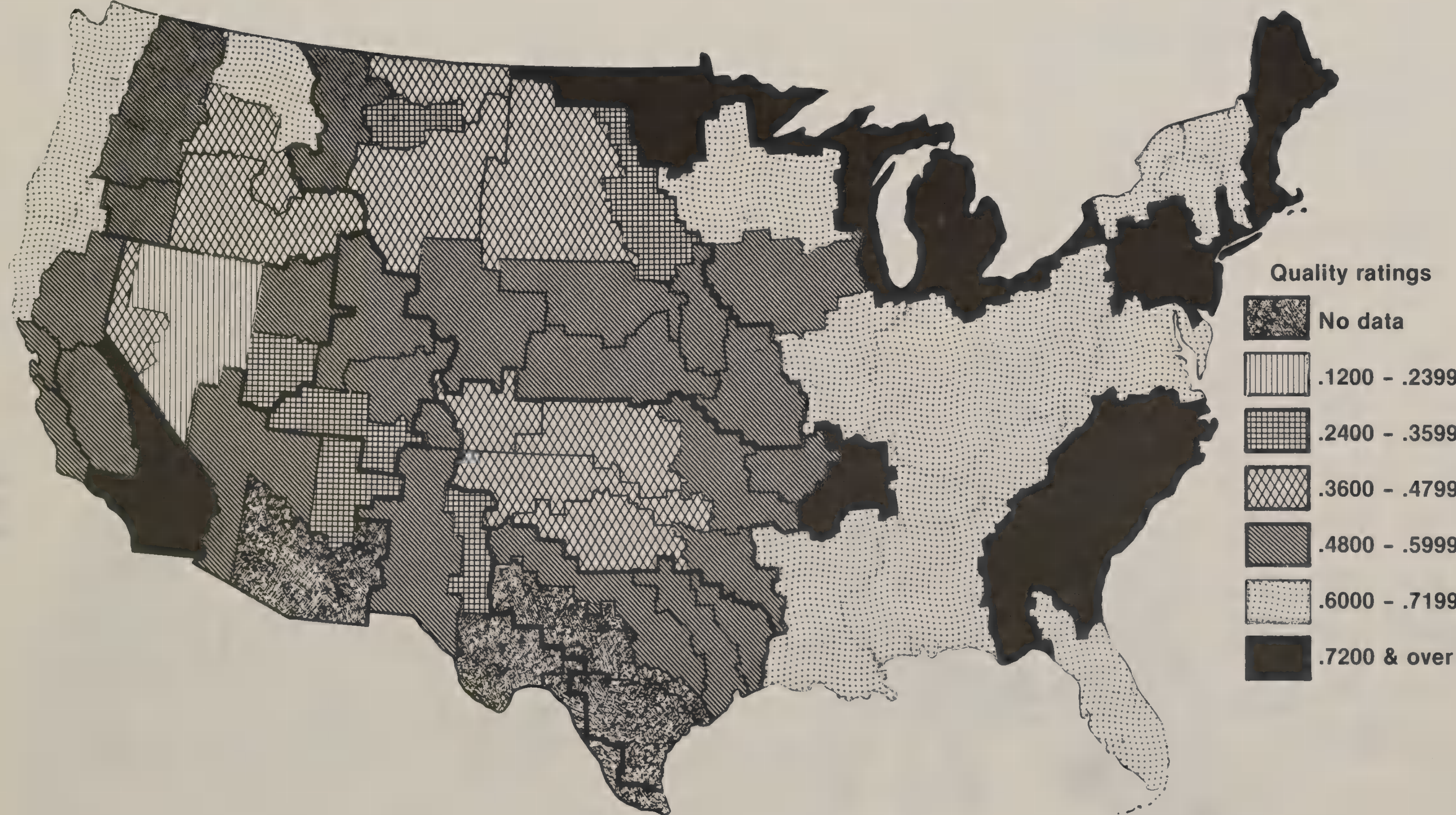


Figure 3D-5.--Average quality ratings for wildlife habitat on forest land, by ASA. (USDA, 1978)

1. Rangeland needing no treatment is better habitat than rangeland needing protection or improvement.
2. Rangeland that has flooding problems or that includes wetlands is better wildlife habitat than rangeland that does not have flooding problems.
3. Installed practices, including brush management and range seeding, improve the quality of the habitat.

Factors that contribute to habitat quality on rangeland or native pasture were assigned the following weighted values:

No treatment needed	= 10, or treatment needed = 3
Brush management applied	= 1
Range seeding applied	= 1
Wetland type 3-20, or common flooding	= 2
	14 = standard value

Figure 3D-6 shows quality ratings for wildlife habitat on rangeland and native pasture, by ASA. Average habitat quality on rangeland is generally lowest in the West, where overgrazing causes poorer range condition. Highest quality ratings for habitat on rangeland and native pasture are in the South and Northeast, where pasture condition is better.

The quality ratings for wildlife habitat on pastureland were based on the following assumptions:

1. Pastureland needing no treatment provides better habitat than pastureland needing protection or improvement.
2. Pastureland that has flooding problems or that includes wetlands is better wildlife habitat than pastureland that does not have flooding problems.

Factors that contribute to habitat quality on pastureland were assigned the following weighted values:

No treatment needed	= 10, or treatment needed = 3
Wetland type 3-20, or common flooding occurs	= 2
	12 = standard value

Wetlands.--Table 3D-2 lists the acres of wetland types 3-20 (Shaw and Fredine, 1956) in each ASA in the 48 conterminous states. Figure 3D-7 shows the distribution of wetland types 3-20. Wetland types 1 and 2 were not inventoried, but the total acreage was estimated. Because these two wetland types are subject to seasonal flooding, figure 3D-8, which shows where flooding is common, indicates the relative abundance of types 1 and 2. USDA estimates that over the past 23 years, wetlands have been lost at an average rate of 500,000 acres per year. In recent years, however, the rate has probably been reduced to about 300,000 acres per year.

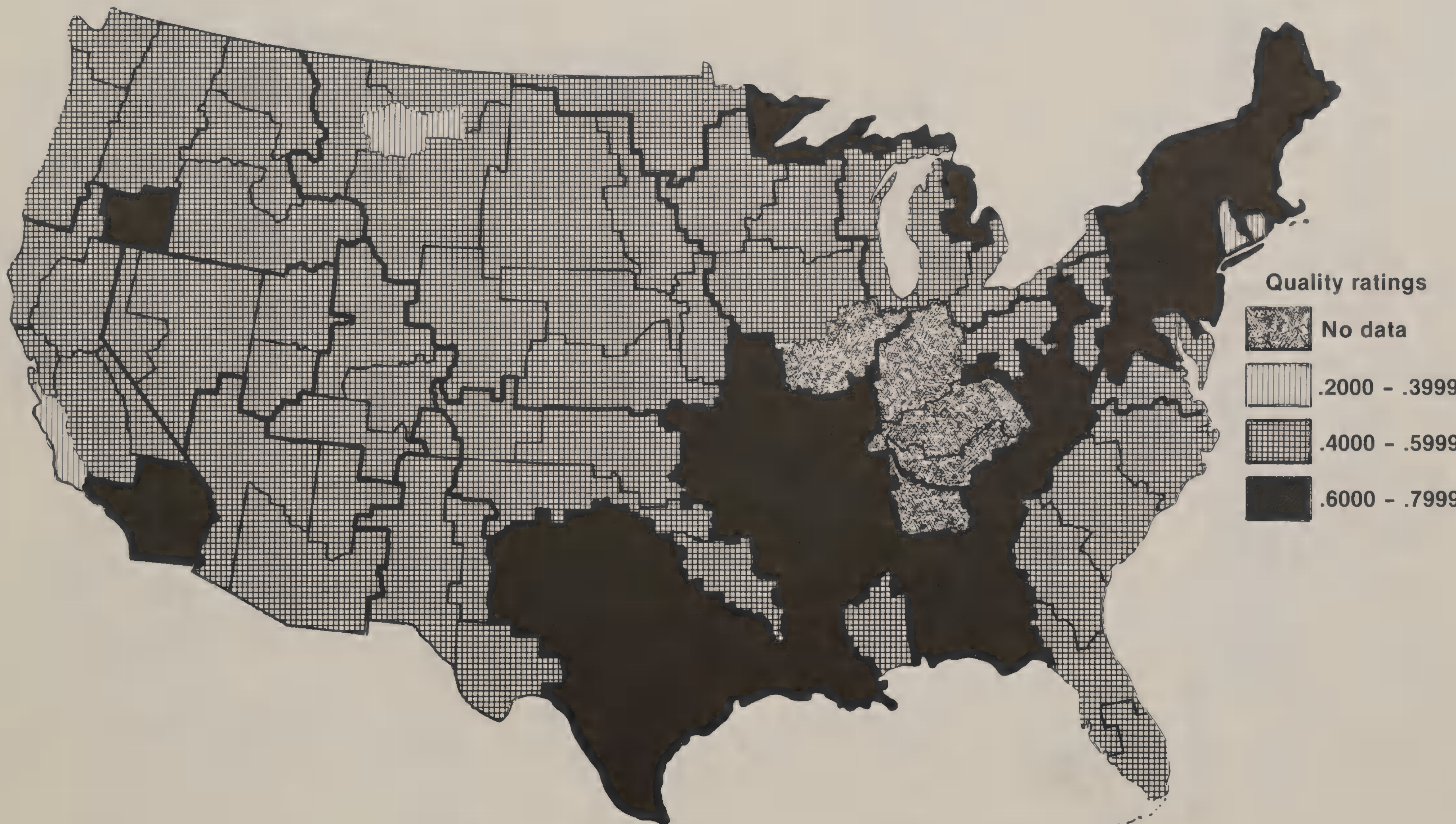


Figure 3D-6.--Average quality ratings for wildlife habitat on rangeland and native pasture, by ASA. (USDA, 1978)

Table 3D-2.--Acreage of wetland types 3-20, by ASA

ASA	Wetland acres	ASA	Wetland acres	ASA	Wetland acres
101	1,119,000	505	36,000	1202	173,000
102	214,000	506	71,000	1203	44,000
103	391,000	507	14,000	1204	0
104	154,000	601	13,000	1205	55,000
105	215,000	602	53,000	1301	0
106	73,000	701	2,485,000	1302	0
201	363,000	702	1,337,000	1303	0
202	24,000	703	149,000	1304	0
203	284,000	704	139,000	1305	191,000
204	48,000	705	29,000	1401	50,000
205	486,000	801	349,000	1402	39,000
206	79,000	802	341,000	1403	18,000
301	2,119,000	803	5,054,000	1501	0
302	1,398,000	901	3,611,000	1502	0
303	2,676,000	1001	248,000	1503	2,000
304	2,629,000	1002	184,000	1601	1,072,000
305	1,469,000	1003	14,000	1602	28,000
306	1,508,000	1004	48,000	1603	73,000
307	418,000	1005	383,000	1604	64,000
308	319,000	1006	547,000	1701	72,000
309	440,000	1007	115,000	1702	79,000
401	1,835,000	1008	461,000	1703	130,000
402	1,278,000	1009	9,000	1704	20,000
403	164,000	1010	101,000	1705	137,000
404	1,136,000	1011	116,000	1706	102,000
405	424,000	1101	0	1707	0
406	247,000	1102	84,000	1801	117,000
407	141,000	1103	53,000	1802	81,000
408	637,000	1104	8,000	1803	85,000
501	44,000	1105	55,000	1804	58,000
502	33,000	1106	5,000	1805	0
503	29,000	1107	0	1806	43,000
504	4,000	1201	234,000	1807	37,000

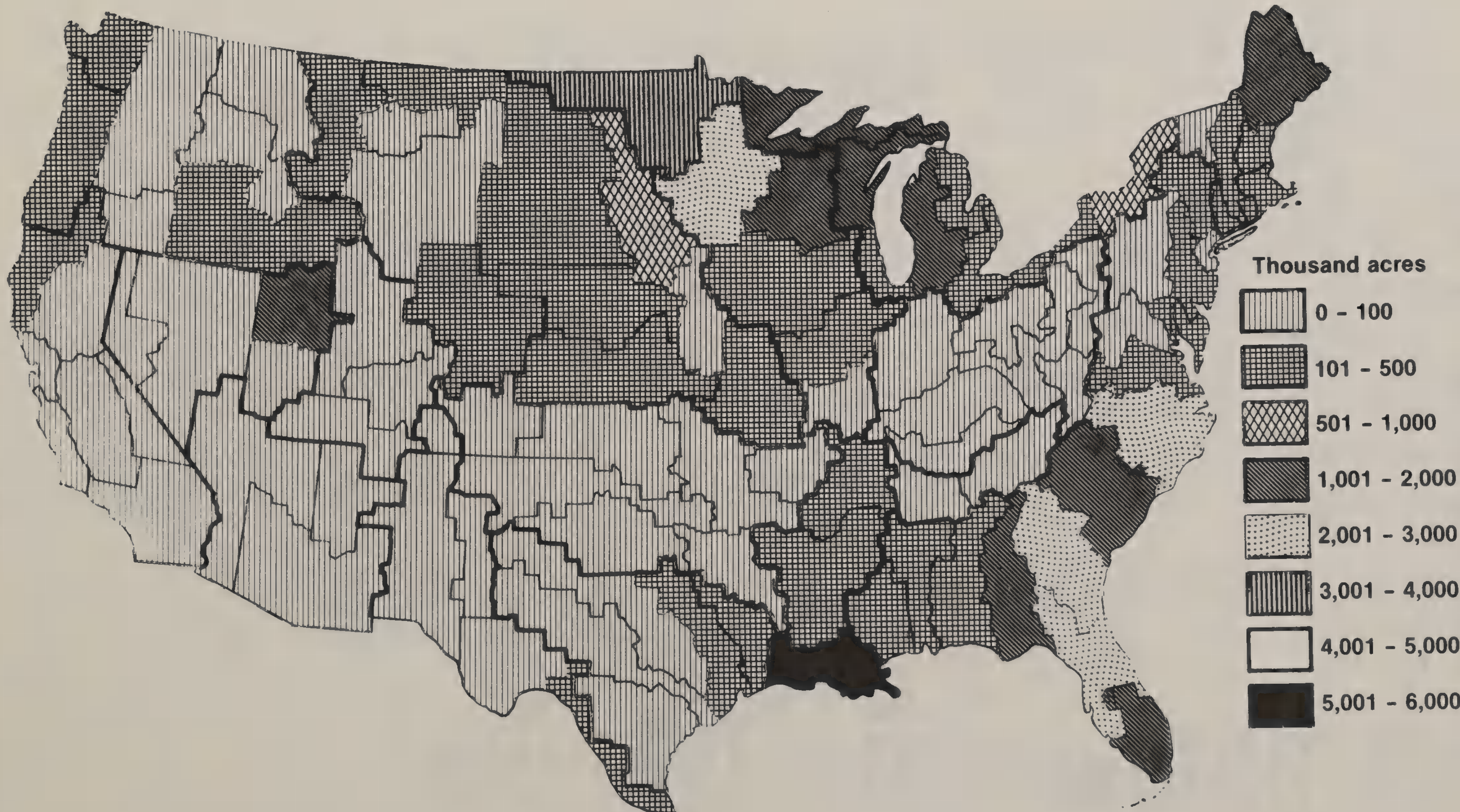


Figure 3D-7.--Acreage in wetland types 3-20, by ASA. (USDA, 1978)

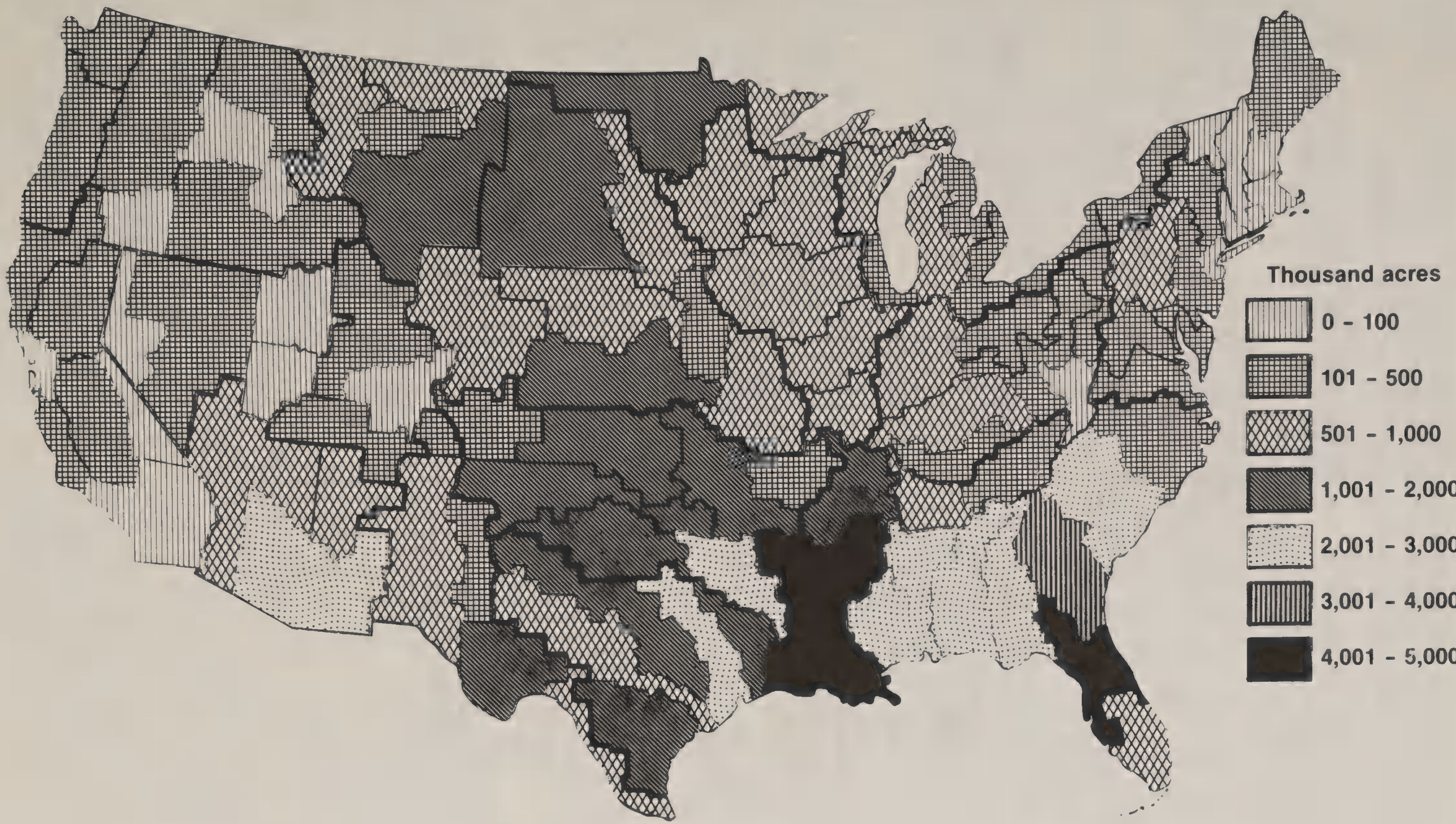


Figure 3D-8.--Aggregated subareas (ASA's) reporting flooding as a dominant or secondary problem. (USDA, 1978)

Fish habitat.--The levels of pollutants in the water, the level of streamflow, and the management of farm ponds all have a significant bearing on fish habitat. These factors are described in the following paragraphs.

o Water Quality.--The factors of water quality that are most important for fish are the levels of nutrients, pesticides, and sediment. For additional information, see section B, Water Quality.

Where water bodies have low nutrient concentrations--southern farm ponds for example--nutrient fertilizers are added to stimulate the growth of plankton and fish populations. In other parts of the country, where water bodies have excessive nutrient concentrations as a result of agricultural runoff, the large blooms of algae or growths of aquatic vegetation that occur eventually die and deplete the oxygen supply. This kills fish.

Excessive nutrient concentrations from agriculture generally occur in intensively farmed areas where commercial fertilizers are applied on large acreages. Although a variety of commercial fertilizers are used nationally, the main fertilizer elements that affect fish populations are nitrogen and phosphorus. Nutrients are also contained in runoff and leaching from animal wastes in confined units and waste disposed on land.

It is difficult to measure the total effect of nutrients on water quality and fish populations nationally because the interactions between nutrients and the aquatic food chain are complex. Because the total effect of nutrients is difficult to assess, specific problem areas where fish are harmed by nutrients have not been identified. Where nutrients from agricultural land have damaged water quality, it is probable that nutrients have damaged fish habitat.

Some commonly used pesticides are highly toxic to fish and other aquatic life and can persist in the environment for many years. Some pesticides that do not present a threat at low levels persist in the environment for years. These compounds accumulate in the aquatic food chain, reaching high levels of concentration in the predatory organisms at the top of the chain. This process is referred to as biological magnification. It reduces vigor and environmental resistance in affected organisms and kills many fish. Fish are most likely to be affected by pesticide pollution where pesticide concentrations from nonpoint sources are highest (see fig. 5B-7, RCA Appraisal 1980, Part I, page 5-31).

Because it is so common and damages water quality in so many ways, sediment is considered the most severe pollutant affecting fish habitat. USDA estimates that half of the 4,145,685,000 tons of soil lost as a result of sheet and rill erosion wash into streams and lakes. About 1.3 billion tons are trapped in reservoirs, and 500 million tons are carried to sea. The rest is deposited on flood plains or accumulated in streams.

The addition of large amounts of sediment changes the community of aquatic organisms within a water body and reduces the total productivity. Sediment covers eggs and spawning areas of fish and other organisms, clogs gills, reduces light transmission and photosynthetic activity, carries absorbed pesticides and nutrients, and reduces the capability of water bodies. Fine sediment is of particular concern because it attracts available pesticides or

nutrients and remains in suspension. Figure 5B-6, RCA Appraisal 1980, Part I, page 5-31 shows areas where sediment is most likely to damage fish habitat.

o Streamflow.--Adequate streamflow satisfies the needs for: (1) instream uses, such as hydropower generation, navigation, water conveyance, water assimilation, recreation, esthetics, estuarine inflow, and maintenance of aquatic and riparian ecosystems, and (2) offstream uses, such as irrigated agriculture, municipal water requirements, and industrial water requirements. For detailed data on the instream flow approximation, see section C, Water Supply and Conservation.

The Second National Water Assessment (USWRC, 1978a-c) provided the first nationwide examination of instream flow conditions and the implications of accelerated offstream uses. The requirements for both consumed and nonconsumed water in the 99 ASA's in the conterminous United States were compared to supplies. The minimum instream flow requirements for fish and wildlife were estimated. The estimates were based on professional judgement and the best information available concerning the needs of fish and wildlife for instream flow.

Figure 3D-9 shows the ASA's in which the average annual streamflow does not supply the estimated required flow for fish and wildlife. Figure 3D-10 shows the ASA's in which the estimated required flow for fish and wildlife is not met during the critical month of an average year.

o Pond management.--USDA inventory data recorded a total of 2,497,983 farm ponds in the United States. About 70 percent provide fishing or home use aquaculture. USDA estimates that the size, location, water quality, or water supply limits fish production potential in about 10 percent of the ponds that presently do not provide fishing or home aquaculture. Therefore, 90 percent, or 696,143, of the ponds which presently do not provide fishing, have suitable water and could be improved.

Focus

For each land use the quality of the habitat for wildlife is most affected by a specific practice. Residue management would improve the quality of habitat on cropland. Grazing is most damaging to habitat on forest land. Poor grazing management is the most severe problem on rangeland and native pasture. USDA could achieve the greatest improvement by directing time and money to those practices. For fish habitat, the USDA program should be directed toward selected water quality and instream flow problems.

Cropland.--In 14 ASA's less than 10 percent of the cropland had residue management in 1977 (fig. 3D-11). In many of the ASA's where residue use is low, for example, New England and the Desert Southwest, crops are not the dominant land use. Where cropland is a dominant use, however, failure to apply residue management is a more serious problem. None of the ASA's in the Upper Mississippi region, where much of the Nation's grain is produced, has residue management on more than 40 percent of the cropland. On ASA's 1805 and 1806 in Southern California, where irrigated row crops are dominant, less than 20 percent of the cropland has residue management.

Figure 3D-9.--Aggregated subareas (ASA's) in which the average annual streamflow is not sufficient for fish and wildlife. (USWRC, 1978)

Figure 3D-10.--Aggregated subareas (ASA's) in which the streamflow during the critical month of an average year is not sufficient for fish and wildlife. (USWRC, 1978)

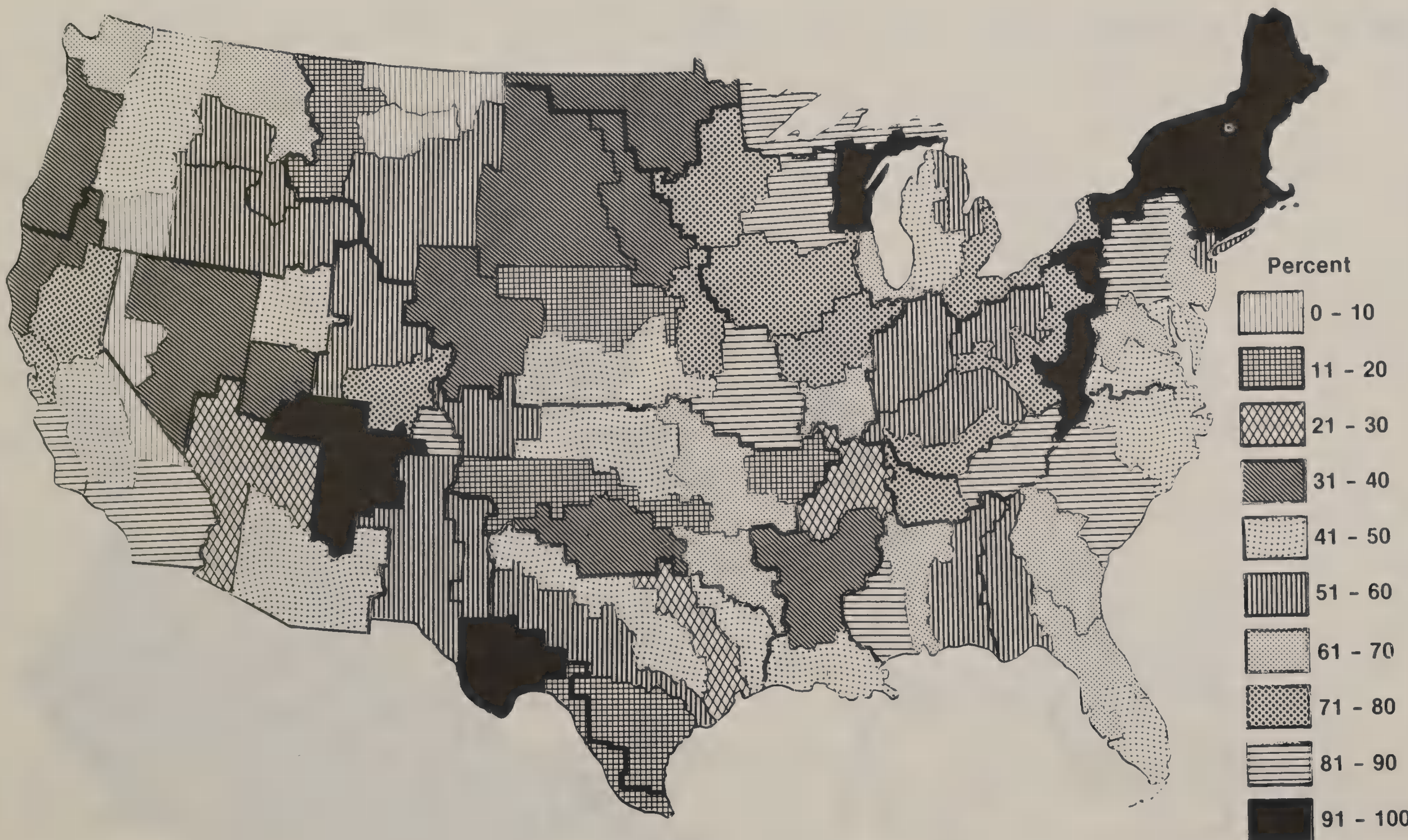


Figure 3D-11.--Percentage of cropland without residue management, by ASA. (USDA, 1978)

If residue management were applied on all cropland, the habitat quality ratings could be improved at least 40 percent in 32 ASA's and at least 20 percent in 73 ASA's (fig. 3D-12). Lower levels of residue management would achieve correspondingly lower increases in habitat quality ratings.

Forest land.--Figure 3D-13 shows the percentage of forest land that is grazed. Most of the grazed forests are west of the Mississippi River. In eight ASA's almost all of the forest land is grazed. Very few areas in the South, Northeast, Upper Midwest, and Great Lakes States are heavily grazed, but most forest areas of the West are grazed and, in many instances, need protection and improvement.

Figure 3D-14 shows the potential increase in habitat quality that could occur if good grazing management were applied on all forest land. Habitat quality could be improved by at least 11 percent in 33 ASA's.

Rangeland.--ASA's in the Great Plains and West show the greatest potential for improvement through treatment (fig. 3D-15). Good management would increase the quality rating 50 percent or more in 19 ASA's and 25 percent or more in 60 ASA's.

Wetlands.--Programs designed to reduce the annual rate of loss of wetlands by 75 percent would save 375,000 acres a year from alteration and destruction. Reducing the rate of loss by 50 percent would save 250,000 acres, and by 25 percent, 125,000 acres. Efforts would be aimed at ASA's with wetlands important for nesting and rearing, for example, ASA's 901, 1005, and 1006, and to ASA's with important wintering habitat, for example, ASA's 802, 803, and 1107. Efforts would also be directed at ASA's with small amounts of wetlands in major flyways, for example, ASA's 1803, 1804, and 1805.

Alternative Objective Levels

Objective level 1 would provide for a program to improve the quality of habitat on cropland, forest land, and rangeland; increase diversity on cropland; reduce the annual loss of wetlands; and improve fish habitat.

1. Wildlife habitat quality would be improved through--
    a. applying residue management on all cropland, increasing stripcropping, and increasing hedgerow or windbreak planting.
    b. applying good grazing management on all forest land and eliminating grazing on all areas where necessary.
    c. applying good grazing management on all rangeland.
2. Wildlife habitat diversity on cropland would be improved by installing a variety of land uses, both short and long term, in areas that are dominantly cropland. Wetlands would be protected for their value in enhancing diversity.
3. The annual loss of wetlands would be reduced by 75 percent.
4. Habitat quality for fish would be improved by treating 75 percent of the critical water quality problems in the 20 most critical ASA's, 50 percent of the critical water quality problems in the next 20 most critical ASA's, and 20 percent of the critical water quality problems in the remaining ASA's.
5. Instream flow requirements would be met as estimated.

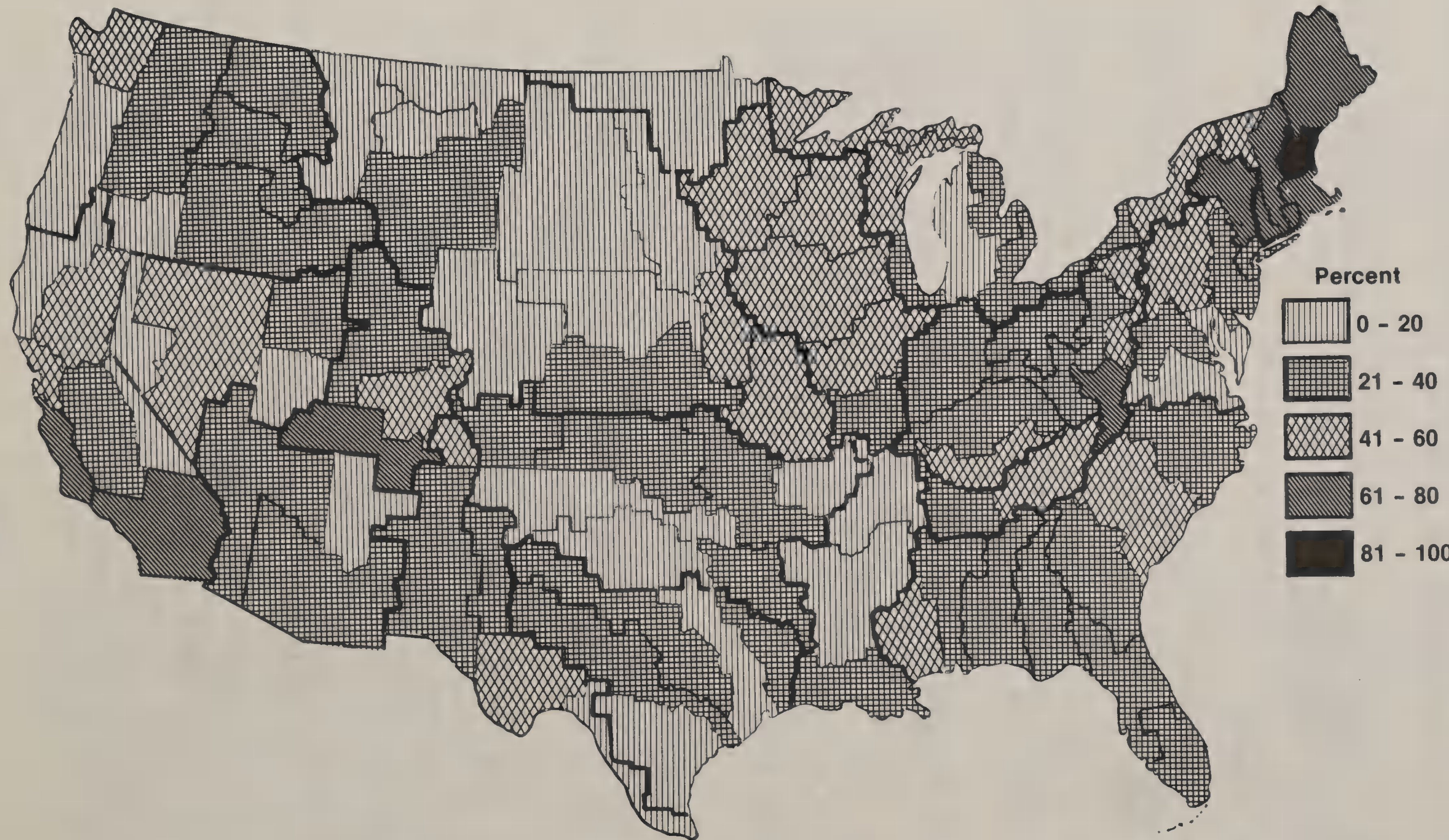


Figure 3D-12.--Potential increase in habitat quality ratings after applying residue management on all cropland, by ASA. (USDA, 1978)

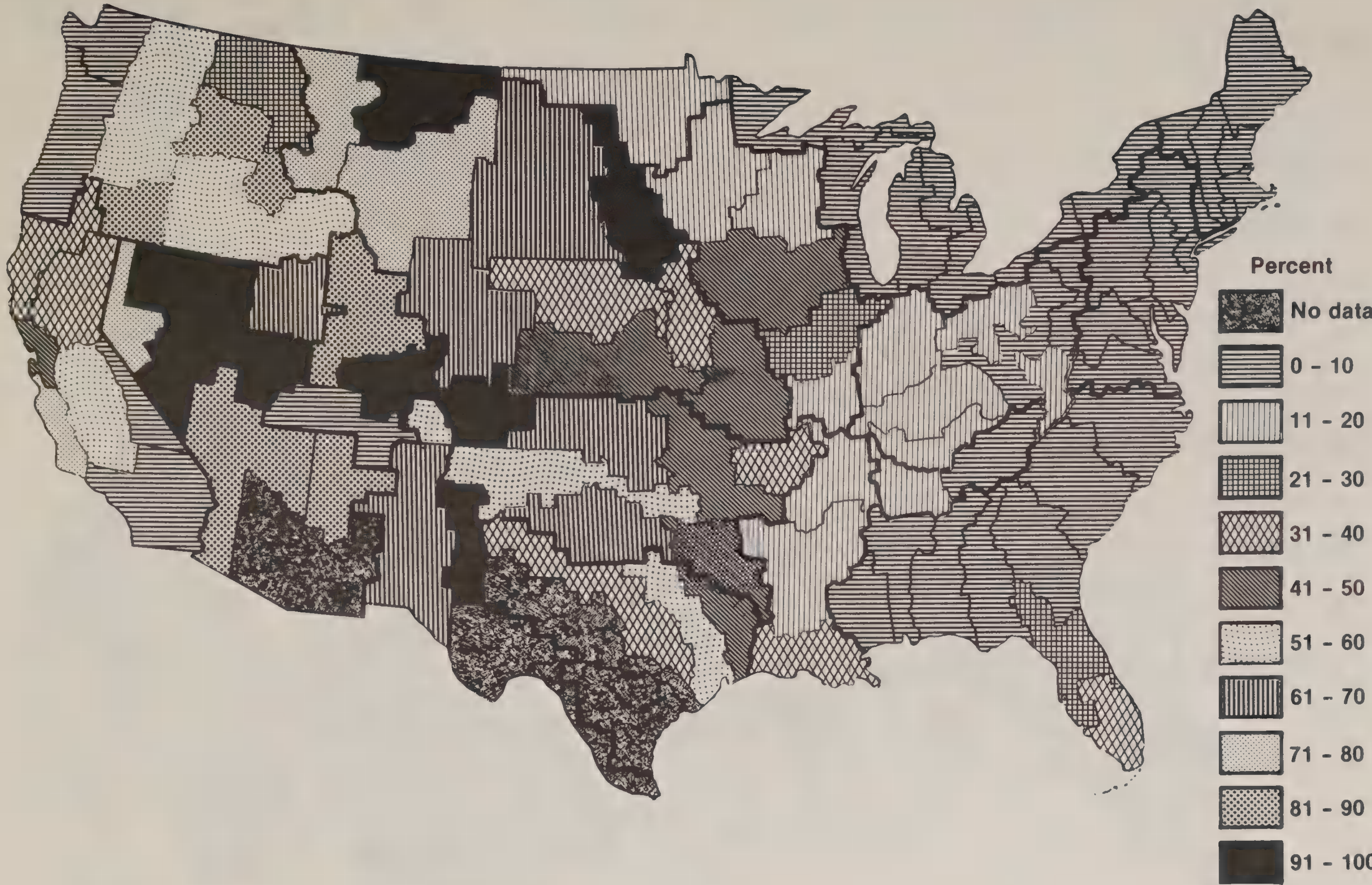


Figure 3D-13.--Percentage of forest land that is grazed, by ASA. (USDA, 1978)

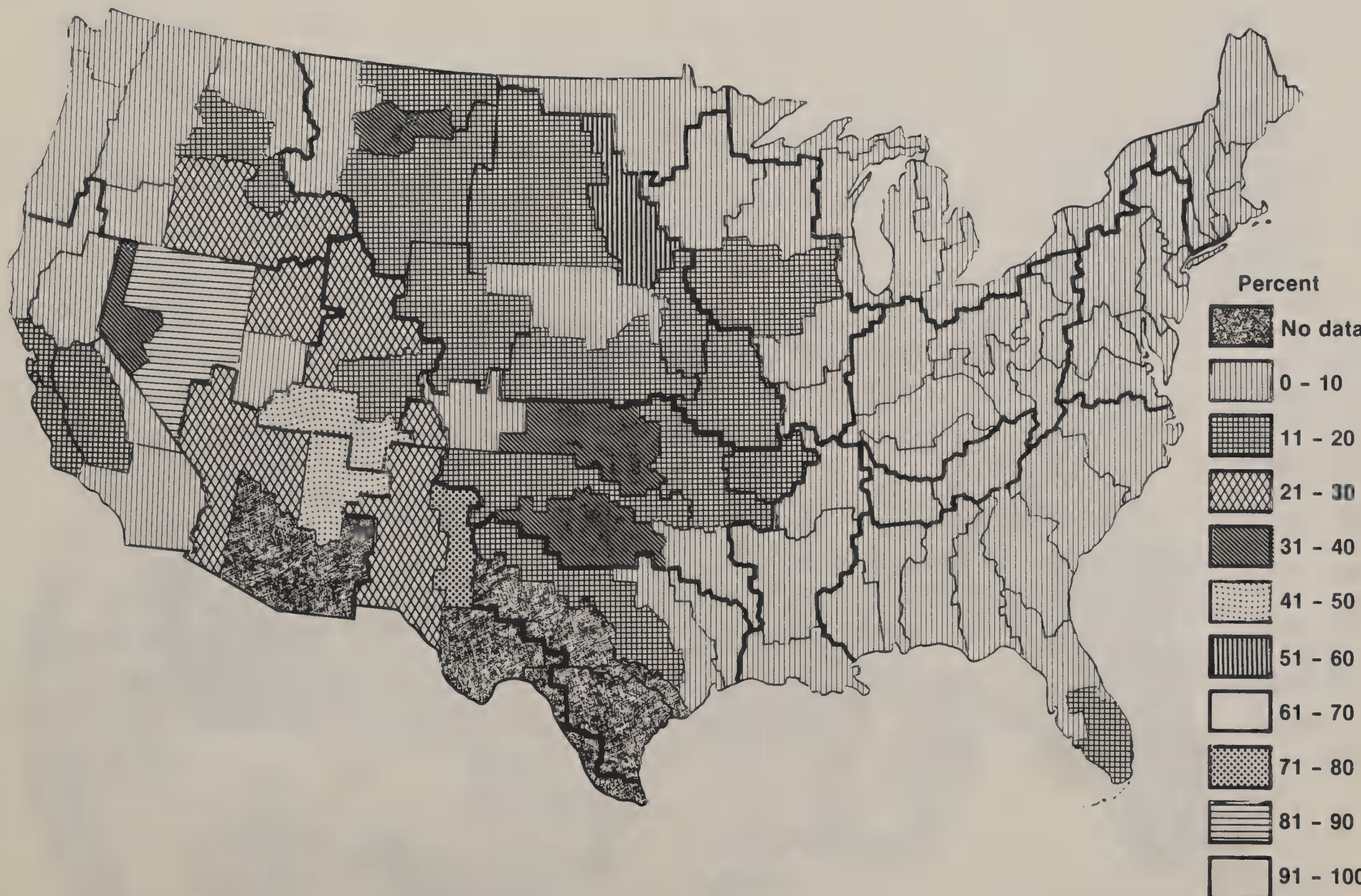


Figure 3D-14.--Potential increase in habitat quality ratings after applying good grazing management on all forest land, by ASA. (USDA, 1978)

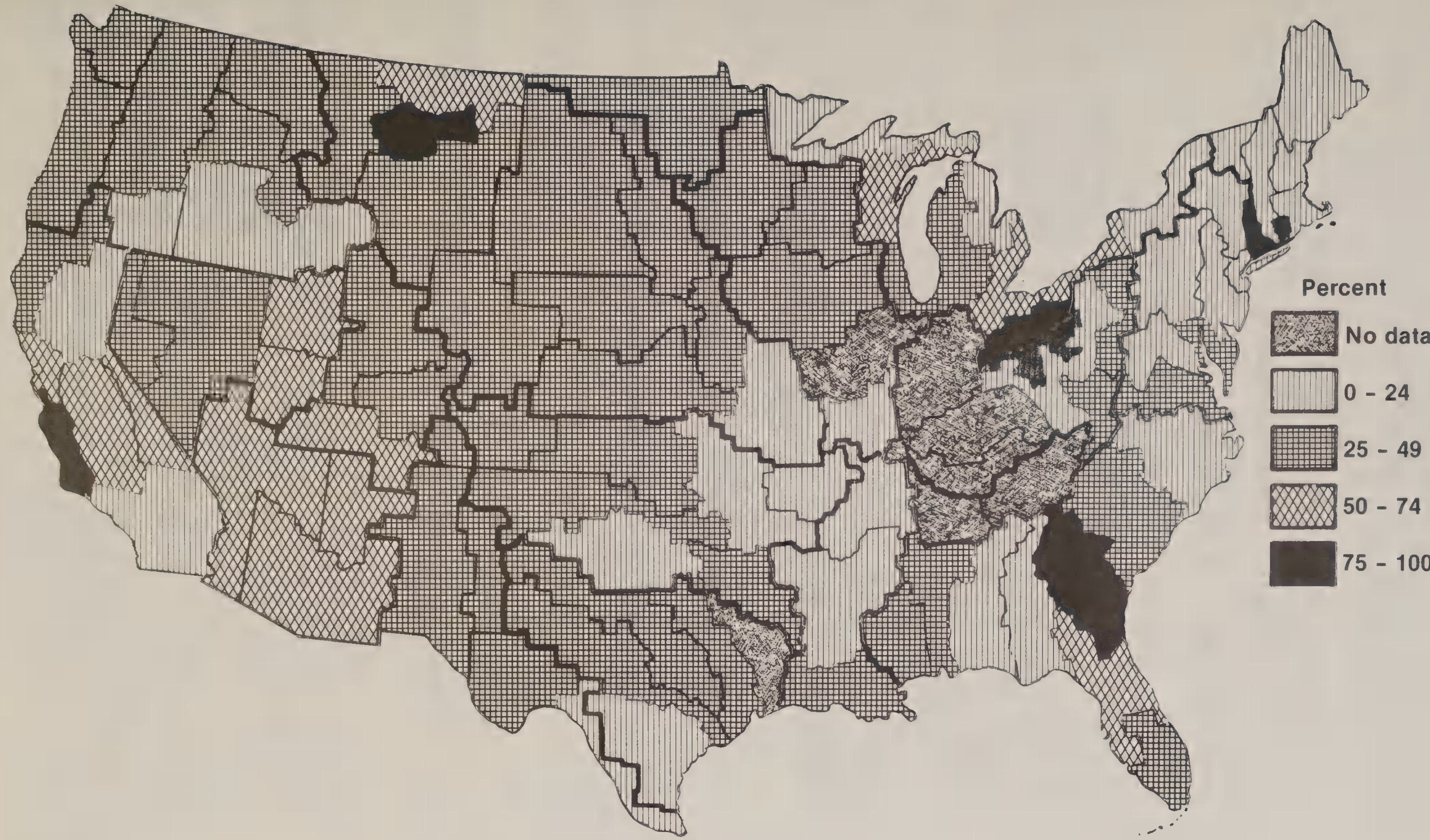


Figure 3D-15.--Potential increase in habitat quality ratings after treatment on rangeland and native pasture, by ASA. (USDA, 1978)

6. Each year, the quality of 8,000 farm fish ponds that do not meet identified management needs would be improved.
7. The need for conservation, development, and use of privately owned or leased land and water for aquaculture identified in the USDA Aquaculture Plan would be met.

Objective level 2 also would emphasize improving the quality of habitat on cropland, forest land, and rangeland. It would provide for improvement or maintenance of diversity on cropland primarily through the increased use of factors such as windbreaks and strip crops. The annual rate of loss of wetlands would be reduced. Specific goals would be as follows:

1. Wildlife habitat quality would be improved through--
    a. applying good residue management where an increase in quality of at least 21 percent could be obtained, increasing stripcropping, and increasing windbreak or hedgerow planting.
    b. treating areas of forest land needing good grazing management where an increase in quality of at least 11 percent could be obtained and eliminating grazing in some areas, mainly riparian woodlands or stream corridors.
    c. applying good grazing management mainly on western rangelands, where an increase in quality of more than 25 percent could be obtained.
2. Fish habitat would be improved by treating 50 percent of the critical water quality problems in the 20 most critical ASA's, 25 percent of the critical water quality problems in the next 20 most critical ASA's, and 10 percent of the critical water quality problems in the remaining ASA's.
3. The annual loss of wetlands would be reduced by 50 percent.
4. Fifty percent of the estimated instream flow requirements would be met.
5. Each year the quality of 4,000 farm fish ponds that do not meet identified management needs would be improved.
6. The need for conservation, development, and use of privately owned or leased land and water for aquaculture identified in the USDA Aquaculture Plan would be met.

Objective Level 3 also would provide for a program to improve the habitat quality on cropland, forest land, and rangeland and to reduce wetland loss. Specific goals would be as follows:

1. Habitat quality would be improved through--
    a. applying residue management where an increase in quality of at least 41 percent could be obtained, increasing stripcropping, and increasing windbreak and hedgerow planting.
    b. treating forest land needing good grazing management where an increase in quality of at least 41 percent could be obtained.
    c. applying good grazing management to rangeland where an increase in quality of more than 50 percent could be obtained.
2. The annual loss of wetlands would be reduced by 25 percent.
3. Fish habitat would be improved by treating 25 percent of the critical water quality problems in the 20 most critical ASA's and 5 percent of the critical water quality problems in the remaining ASA's.

4. Twenty percent of the instream flow requirements would be met.
5. Each year the quality of 2,000 farm fish ponds that do not presently meet identified management needs would be improved.
6. The need for conservation and development of privately owned or leased land and water for aquaculture identified in the USDA Aquaculture Plan would be met.

References

Hirsh, Allan, Wm. B. Kaohn, D. Schweitzer, and Carl Thomas. 1979. Trends and needs in federal inventories of wildlife habitat. Presented at the 44th North American Wildlife and Natural Resource Conference, Toronto, Ontario, Canada, March 24-28, 1979.

Shaw, Samuel P., and C. Gordon Fredine. 1956. Wetlands of the United States. U.S. Dep. Int., Fish Wildl. Serv. Circ. 39. 67 pp.

United States Department of Agriculture, Soil Conservation Service. 1978. 1977 National resource inventories.

United States Water Resources Council. 1978a. The Nation's water resources 1975-2000. Second Natl. Water Assess. Stat. Append. Vol. A-2, Part 1. (Draft)

United States Water Resources Council. 1978b. The Nation's water resources 1975-2000. Functional uses. Second Natl. Water Assess. Part III. (Draft)

United States Water Resources Council. 1978c. The Nation's water resources 1975-2000. Second Natl. Water Assess. Vol. I: Summary.

Section E-Potential Problem Area 5, Upstream Flood Damages

Problem Statement

The RCA public meetings indicated that flooding is a major resource concern. Flooding was mentioned as a concern in 1,262 of the 3,485 worksheets filled out for RCA public meetings in 1978. It was ranked as the seventh highest resource concern.

Floods occur whenever the water in a stream, lake, or bay can no longer be contained within natural or artificial banks. Thunderstorms, generally in summer, pose the greatest threat to small watersheds because intensive rainfall of short duration can cover small areas and cause heavy local damage. Excessive runoff from snowmelt or rainfall or from a combination of the two on frozen ground is responsible for most spring floods in the northern United States. Hurricanes and the accompanying tidal flooding endanger Gulf and Atlantic coastal areas.

There are 175 million acres of flood plains (see glossary) on nonfederal rural lands in the United States excluding Alaska (USDA, 1978). This acreage is 9 percent of the total surface area of the conterminous United States. Of this acreage, 48 million acres are used for cropland, 20 million for native pasture and pastureland, 35 million for rangeland, 52 million for forest land, and 20 million for other uses, such as urban development and roads (USDA, 1978). About 9 percent of the Nation's cropland is on flood plains, including 9.5 million acres that are irrigated.

About 16 percent of the Nation's 346 million acres of prime farmland are on flood plains. Twenty-four million acres of prime farmland on flood plains have high potential for cropland and 31 million acres have medium potential. In 1977, 60 percent of the prime farmland on flood plains was cropped (USDA, 1978).

The improper or unwise use of flood plains is a nationwide problem. The problem is particularly serious where the flood plain is used for competing and incompatible purposes, such as urban growth, energy development, and intensive crop production. All of these uses are subject to some damage from flooding. The extent of damage depends on the intensity of use, the location of the use within the flood plain, and the characteristics of the flooding. Some uses aggravate the flood hazard.

Methodology.--Charles W. Williams, Inc., Policy Research and Assistance, of Alexandria, Virginia, assembled data concerning flood damages for analysis in this report. Because of time restrictions, the consultant used readily available data.

For Williams' report, the U.S. Department of Agriculture defined "upstream" as those main stem and tributary areas with 400 square miles or less of drainage. Where completed river basin studies were available, the report used upstream and downstream as defined in the river basin study, rather than the 400 square mile definition. To avoid overlapping and duplication, USDA used the exact points of upstream-downstream divisions that the U.S. Army Corps of Engineers uses.

USDA used data from existing river basin studies, the Conservation Needs Inventory, watershed reports, studies by state agencies, reports of river basin commissions, and other sources. It used the 1972 OBERS Series E Projections (USWRC, 1974) to obtain income and earning data for use in making flood damage projections. It collected no new data.

Water conservation personnel from USDA tabulated data on current upstream damages, upstream flood plain areas, urban areas with flood problems, and flood plain reports prepared through fiscal year 1975. They also identified areas with severe flooding problems and recorded areas subject to inundation by 100-year frequency floods. They recorded the flood plain acreage by land uses: urban and built-up land; agricultural cropland, including land in field crops, rotation hay and pasture, and improved pasture; and other land, including forest, range, parks, refuges, mines, roadways, utilities, and farmsteads.

USDA then listed by aggregated subareas (ASA's) (see glossary) the monetary damages, the areas inundated in upstream watersheds, the places with flooding problems, and the number of flood plain reports.

USDA estimated upstream damages by subarea where the data were available and by ASA in every case. The 1975 damages, by type, are expressed in 1967 dollars. USDA then updated dollar damages from existing studies and reports using a two-step process. First, it interpolated damages for 1975 from data for the inventory year of the study and for the first projected year of the study (usually 1980). Second, it adjusted the dollar damage to price base 1967 with appropriate indices prepared by the Department of Commerce. The index "Prices Received by Farmers" was used to adjust damages to agricultural cropland. The index "Implicit Price Deflators for Personal Consumption Expenditures, 1929-1970" was used to adjust urban and built-up and other damages.

USDA used secondary data to estimate damages from areas other than those with river basin studies. It recorded these damage estimates for current physical flood losses and expressed them in 1967 dollars.

Using river basin reports, knowledge of the area, and visual inspection of maps, USDA identified urban areas having flood problems. Urban areas include small communities occupying at least 10 acres; larger boroughs, villages, and towns of less than 2,500 people; and larger towns and cities.

Data were available from several sources. The Federal Insurance Administration directs flood insurance studies. The U.S. Geological Survey prepares flood plain area reports. The Soil Conservation Service makes flood hazard studies and develops watershed protection and flood prevention plans. The Army Corps of Engineers prepares flood plain information reports. The number of these reports to date was recorded for each ASA.

USDA delineated the areas that have the most severe flooding problems on a base map. To identify these areas, it used a list of watersheds where flood prevention is feasible, a list of authorized projects where remaining damages are high, a list of communities with flood problems, and lists of other areas

experiencing floods and threats of floods. No quantitative criteria were used; rather, field technicians familiar with the problems estimated their severity.

Finally, USDA projected damages to 1985 and 2000 under three different levels of regulation. These levels are: (1) that flood plains will be regulated at a constant level, (2) that the present regulation trend will continue, and (3) that regulation will be increased to the maximum practicable. The figures for personal income, per capita income, and agricultural earnings that USDA used to project damages are those shown in the 1972 OBERS Series E Projections (USWRC, 1974) and in "Population, Economic Activity and Water Use Projections" for the Virgin Islands and Puerto Rico.

Summary of damages.--Flood damages to cropland and pastureland, urban land, and other properties in upstream areas were slightly more than $1 billion in 1975 (in constant 1967 dollars). Estimated damages for the year 2000 are about $1.4 billion (table 3E-1). Damages to cropland and pastureland accounted for just under $670 million, or 63 percent of the 1975 damages, and occurred on about 58,586,000 acres (table 3E-2). Damages to cropland and pasture in 2000 are projected to rise to about $680 million. Damages to urban property were almost $200 million in 1975 and are projected to be more than $360 million in 2000 (table 3E-3). Other upstream damages were about $200 million in 1975 and are projected to slightly exceed $370 million in 2000 (table 3E-4).

People occupying the flood plain are not the only ones who suffer losses. Others are affected by the disruption of the economy during and after the flood and by the cost of relief and reconstruction in the area.

The threat to human life and health posed by floods cannot be adequately described in monetary terms. Floods killed 3,738 people between 1925 and 1970. Actuarial estimates show that in 20 years out of 100, fewer than 30 people die from floods, but in another 20 years of 100, more than 100 people die. Although the number of deaths varies widely from year to year, the general trend seems to be downward (USWRC, 1977).

Flooding disrupts the natural environment in a variety of ways. Fast flowing water erodes banks and disrupts channels. The food and cover in streams are often severely damaged by physical disturbance and sedimentation. Eggs and young fish are suffocated or swept away. Aquatic organisms are trapped away from the main stream body when floodwaters recede. Small ground-dwelling animals living within the flood plain often drown. The eggs and young of ground nesting birds are destroyed. Sedimentation from floods sometimes damages downstream fisheries and alters their chemical quality.

The magnitude of damages for cropland, pasture, urban land, and other lands varies significantly in different sections of the country. In 19 ASA's, cropland and pasture damages are high (fig. 3E-1 and table 3E-2). In 10 ASA's, urban damages are high (fig. 3E-2 and table 3E-3). In 11 ASA's flood damages on other land are high (fig. 3E-3 and table 3E-4) (Williams, 1979).

Table 3E-1.--Upstream flood damages for 1975 with projections for 2000

Water resources regions	Cropland and pasture		Urban		Other		Total	
	1975	2000	1975	2000	1975	2000	1975	2000
	(Thousands of 1967 dollars)							
New England---------	1,660	1,728	18,784	33,799	4,706	8,512	25,150	44,039
Mid-Atlantic--------	17,376	17,005	20,597	37,293	3,507	6,254	41,480	60,552
South Atlantic-Gulf-	151,980	156,297	45,934	85,492	61,129	115,395	259,043	357,184
Great Lakes---------	10,607	10,586	3,151	5,709	670	1,210	14,428	17,505
Ohio----------------	32,979	33,251	13,412	24,703	12,581	23,824	58,972	82,778
Tennessee-----------	15,677	15,514	5,070	9,944	8,042	15,773	28,789	41,231
Upper Mississippi---	46,162	47,560	5,118	9,325	17,859	32,519	69,139	89,404
Lower Mississippi---	113,891	117,279	8,852	16,842	14,824	28,512	137,567	162,633
Souris-Red-Rainy----	7,131	7,316	208	388	2,650	4,937	9,989	12,641
Missouri------------	79,732	84,271	11,283	20,679	24,186	44,190	115,201	149,140
Arkansas------------	76,072	74,053	10,427	20,330	13,805	26,306	100,304	120,689
Texas-Gulf----------	23,027	22,093	1,673	3,067	5,458	9,995	30,158	35,155
Rio Grande----------	14,753	15,418	4,355	8,049	1,611	2,975	20,719	26,442
Upper Colorado------	631	766	536	998	533	984	1,700	2,748
Lower Colorado------	7,205	7,508	24,487	42,573	7,366	12,664	39,058	62,745
Great Basin---------	619	669	1,489	2,673	1,002	1,780	3,110	5,122
Pacific Northwest---	32,333	31,537	5,095	9,239	5,858	10,533	43,286	51,309
California----------	31,949	34,093	14,081	24,607	14,275	25,487	60,305	84,187
Alaska--------------	9	9	672	1,143	54	92	735	1,244
Hawaii--------------	1,413	1,424	1,750	2,761	9	15	3,172	4,200
Caribbean-----------	946	1,183	484	979	335	681	1,765	2,843
Total----------	666,152	679,560	197,458	361,593	200,460	372,638	1,064,070	1,413,791

Table 3E-2.--Agricultural upstream flood damages by aggregated subarea (ASA) for 1975 and projections for 1985 and 2000

(Modified central case, in 1967 dollars)

Aggregated subarea (ASA)	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage
	1975				1985				2000			
New England-----	1,660	169	9.82	0.3	1,590	169	9.41	0.3	1,728	169	10.22	0.3
101-----------	146	11	13.27	----	167	11	15.18	----	187	11	17.00	----
102-----------	360	30	12.00	----	335	30	11.17	----	363	30	12.10	----
103-----------	496	29	17.10	----	467	29	16.10	----	500	29	17.24	----
104-----------	51	18	2.83	----	45	18	2.50	----	46	18	2.56	----
105-----------	217	36	6.03	----	198	36	5.50	----	207	36	5.75	----
106-----------	390	45	8.67	----	378	45	8.40	----	425	45	9.44	----
Mid-Atlantic----	17,376	1,970	8.82	2.6	15,954	1,970	8.10	2.5	17,005	1,970	8.63	2.5
201-----------	692	34	20.35	----	638	34	18.76	----	685	34	20.15	----
202-----------	97	13	7.46	----	91	13	7.00	----	99	13	7.62	----
203-----------	1,589	373	4.26	----	1,480	373	3.97	----	1,573	373	4.22	----
204-----------	425	101	4.21	----	404	101	4.00	----	436	101	4.32	----
205-----------	11,980	1,243	9.64	----	10,926	1,243	8.79	----	11,645	1,243	9.37	----
206-----------	2,593	206	12.59	----	2,415	206	11.72	----	2,567	206	12.46	----
South Atlantic-												
Gulf----------	151,980	8,266	18.39	22.8	143,094	8,266	17.31	22.9	156,297	8,266	18.91	23.0
301-----------	83,583	1,981	42.19	----	77,832	1,981	39.29	----	84,252	1,981	43.53	----
302-----------	33,566	2,483	13.52	----	31,579	2,483	12.72	----	34,439	2,483	13.87	----
303-----------	6,209	527	11.78	----	5,901	527	11.20	----	6,538	527	12.41	----
304-----------	2,984	328	9.10	----	2,893	328	8.82	----	3,250	328	9.91	----
305-----------	5,862	1,109	5.29	----	5,740	1,109	5.18	----	6,436	1,109	5.80	----
306-----------	4,296	412	10.43	----	4,372	412	10.61	----	5,142	412	12.48	----
307-----------	4,680	454	10.31	----	4,448	454	9.80	----	4,844	454	10.67	----
308-----------	5,838	663	8.81	----	5,661	663	8.54	----	6,305	663	9.51	----
309-----------	4,962	309	16.06	----	4,668	309	15.11	----	5,091	309	12.46	----

Table 3E-2.--Agricultural upstream flood damages by aggregated subarea (ASA) for 1975 and projections for 1985 and 2000--Continued

(Modified central case, in 1967 dollars)

ASA Number	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage
	1975				1985				2000			
Great Lakes--------	10,607	781	13.58	1.6	9,912	781	12.69	1.6	10,586	781	13.55	1.6
401--------------	81	54	1.50	----	83	54	1.54	----	92	54	1.70	----
402--------------	886	22	40.27	----	834	886	37.91	----	893	886	40.59	----
403--------------	156	25	6.24	----	141	156	5.64	----	147	156	5.80	----
404--------------	1,974	134	14.73	----	1,819	1,974	13.57	----	1,919	1,974	14.32	----
405--------------	408	102	4.00	----	368	408	3.61	----	382	408	3.74	----
406--------------	5,653	327	17.29	----	5,318	5,653	16.26	----	5,698	5,653	17.42	----
407--------------	526	32	16.44	----	490	526	15.31	----	525	526	16.41	----
408--------------	923	85	10.86	----	859	923	10.10	----	930	923	10.94	----
Ohio--------------	32,979	2,199	15.00	5.0	30,933	2,199	14.07	4.9	32,251	2,199	15.12	4.9
501--------------	633	76	8.33	----	571	76	7.51	----	598	76	7.87	----
502--------------	2,339	185	12.64	----	2,088	185	11.29	----	2,168	185	11.72	----
503--------------	4,629	408	11.35	----	4,355	408	10.67	----	4,708	408	11.54	----
504--------------	213	61	3.49	----	182	61	2.98	----	186	61	3.05	----
505--------------	7,357	776	9.48	----	6,921	776	8.92	----	7,416	776	9.56	----
506--------------	12,127	571	21.24	----	11,526	571	20.19	----	12,551	571	21.98	----
507--------------	5,681	122	46.57	----	5,290	122	43.36	----	5,624	122	46.10	----
Tennessee----------	15,677	762	20.57	2.4	14,516	762	19.05	2.3	15,514	762	20.36	2.3
601--------------	7,756	308	25.18	----	7,073	308	22.96	----	7,469	308	24.25	----
602--------------	7,911	454	17.43	----	7,443	454	16.39	----	8,045	454	17.72	----
Upper Mississippi--	46,162	4,150	11.12	6.9	43,559	4,150	10.50	7.0	47,560	4,150	11.46	7.0
701--------------	3,253	540	6.02	----	3,159	540	5.85	----	3,543	540	6.56	----
702--------------	1,960	330	5.94	----	1,844	330	5.59	----	2,011	330	6.09	----
703--------------	13,203	1,800	7.34	----	12,828	1,800	7.13	----	14,288	1,800	7.94	----
704--------------	20,452	1,000	20.45	----	19,216	1,000	19.22	----	20,956	1,000	20.96	----
705--------------	7,294	480	15.20	----	6,512	480	13.57	----	6,762	480	14.09	----
Lower Mississippi--	113,891	18,559	6.14	17.1	107,627	18,559	5.80	17.2	117,279	18,559	6.32	17.3
801--------------	49,803	3,285	15.16	----	46,377	3,285	14.12	----	50,201	3,285	15.28	----
802--------------	52,233	6,728	7.76	----	49,642	6,728	7.38	----	54,061	6,728	8.04	----
803--------------	11,855	8,546	1.39	----	11,608	8,546	1.36	----	13,017	8,546	1.52	----

Table 3E-2.--Agricultural upstream flood damages by aggregated subarea (ASA) for 1975 and projections for 1985 and 2000--Continued

(Modified central case, in 1967 dollars)

Aggregated subarea (ASA)	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage
	1975				1985				2000			
Souris-Red-Rainy---	7,131	1,275	5.59	1.1	6,640	1,275	5.21	1.1	7,316	1,275	5.74	1.1
901--------------	7,131	1,275	5.59	----	6,640	1,275	5.21	----	7,316	1,275	5.74	----
Missouri-----------	79,732	7,106	11.22	12.0	76,560	7,106	10.77	12.2	84,271	7,106	11.86	12.4
1001-------------	128	160	0.80	----	128	160	0.80	----	142	160	0.89	----
1002-------------	170	210	0.81	----	153	210	0.73	----	162	210	0.77	----
1003-------------	114	93	1.23	----	104	93	1.12	----	111	93	1.19	----
1004-------------	605	220	2.75	----	552	220	2.51	----	583	220	2.65	----
1005-------------	1,018	1,004	1.01	----	992	1,004	0.99	----	1,109	1,004	1.10	----
1006-------------	3,473	721	4.82	----	3,434	721	4.76	----	3,845	721	5.33	----
1007-------------	2,771	436	6.36	----	2,660	436	6.10	----	2,943	436	6.75	----
1008-------------	5,547	616	9.00	----	5,325	616	8.64	----	5,891	616	9.56	----
1009-------------	7,239	901	8.03	----	6,741	901	7.48	----	7,297	901	8.10	----
1010-------------	15,251	1,140	13.38	----	14,787	1,140	12.97	----	16,471	1,140	14.45	----
1011-------------	43,416	1,565	27.74	----	41,679	1,565	26.63	----	45,717	1,565	29.21	----
Arkansas-White-Red-	76,072	7,212	10.55	11.4	69,832	7,212	9.68	11.2	74,053	7,212	10.27	10.9
1101-------------	7,900	550	14.36	----	7,129	550	12.96	----	7,537	550	13.70	----
1102-------------	433	150	2.89	----	449	150	2.99	----	526	150	3.51	----
1103-------------	11,928	876	13.62	----	11,222	876	12.81	----	12,023	876	13.72	----
1104-------------	21,312	1,690	12.61	----	19,232	1,690	11.38	----	19,948	1,690	11.80	----
1105-------------	10,525	1,172	8.98	----	9,094	1,172	7.76	----	9,283	1,172	7.92	----
1106-------------	15,910	1,229	12.95	----	15,274	1,229	12.43	----	16,753	1,229	13.63	----
1107-------------	8,064	1,545	5.22	----	7,432	1,545	4.81	----	7,983	1,545	5.17	----
Texas-Gulf---------	23,027	1,110	20.75	3.5	21,020	1,110	18.94	3.4	22,093	1,110	19.90	3.3
1201-------------	2,205	236	9.34	----	1,736	236	7.36	----	1,687	236	7.15	----
1202-------------	7,655	196	39.06	----	7,055	196	35.99	----	7,441	196	37.96	----
1203-------------	7,082	387	18.30	----	6,595	387	17.04	----	6,947	387	17.95	----
1204-------------	1,756	172	10.21	----	1,686	172	9.80	----	1,849	172	10.75	----
1205-------------	4,329	119	36.38	----	3,948	119	33.18	----	4,169	119	35.03	----

Table 3E-2.--Agricultural upstream flood damages by aggregated subarea (ASA) for 1975 and projections for 1985 and 2000--Continued

(Modified central case, in 1967 dollars)

Aggregated subarea (ASA)	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage
	1975				1985				2000			
Rio Grande--------	14,753	832	17.73	2.2	14,073	832	16.91	2.2	15,418	832	18.53	2.3
1301------------	168	47	3.57	----	166	47	3.53	----	192	47	4.09	----
1302------------	2,847	377	7.55	----	2,651	377	7.03	----	2,895	377	7.68	----
1303------------	302	30	10.07	----	316	30	10.53	----	375	30	12.50	----
1304------------	1,485	106	14.01	----	1,483	106	13.99	----	1,657	106	15.63	----
1305------------	9,951	272	36.58	----	9,457	272	34.77	----	10,299	272	37.86	----
Upper Colorado----	631	348	1.81	0.1	646	348	1.86	0.1	766	348	2.20	0.1
1401------------	169	146	1.16	----	156	146	1.07	----	173	146	1.18	----
1402------------	239	140	1.71	----	257	140	1.84	----	312	140	2.23	----
1403------------	223	62	3.60	----	233	62	3.76	----	281	62	4.53	----
Lower Colorado----	7,205	1,148	6.28	1.1	6,783	1,148	5.91	1.1	7,508	1,148	6.54	1.1
1501------------	178	45	3.96	----	142	45	3.16	----	144	45	3.20	----
1502------------	1,073	193	5.56	----	1,154	193	5.98	----	1,302	193	7.06	----
1503------------	5,954	910	6.54	----	5,487	910	6.03	----	6,002	910	6.60	----
Great Basin-------	619	41	15.10	0.1	599	41	14.61	0.1	669	41	16.32	0.1
1601------------	261	11	23.73	----	253	11	23.00	----	280	11	25.45	----
1602------------	97	3	32.33	----	89	3	29.67	----	96	3	32.00	----
1603------------	187	25	7.48	----	180	25	7.20	----	202	25	8.08	----
1604------------	74	2	37.00	----	77	2	38.50	----	91	2	45.50	----
Pacific Northwest-	32,333	1,647	19.63	4.9	29,625	1,647	17.99	4.7	31,537	1,647	19.15	4.6
1701------------	1,445	102	14.17	----	1,346	102	13.20	----	1,444	102	14.16	----
1702------------	5,742	248	23.15	----	5,402	248	21.78	----	5,788	248	23.34	----
1703------------	7,595	362	20.98	----	7,291	362	20.14	----	8,134	362	22.47	----
1704------------	3,598	122	29.49	----	3,212	122	26.33	----	3,400	122	27.87	----
1705------------	4,743	417	11.37	----	4,417	417	10.59	----	4,738	417	11.36	----
1706------------	8,394	277	30.30	----	7,252	277	26.18	----	7,328	277	26.45	----
1707------------	816	119	6.86	----	705	119	5.92	----	705	119	5.92	----

Table 3E-2.--Agricultural upstream flood damages by aggregated subarea (ASA) for 1975 and projections for 1985 and 2000--Continued

(Modified central case, in 1967 dollars)

Aggregated subarea (ASA)	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage	Dollars (thousands)	Acres (thousands)	Dollars per acre	Regional percentage of dollar damage
	1975				1985				2000			
California--------	31,949	900	35.50	4.8	30,742	900	34.16	4.9	34,093	900	37.88	5.0
1801------------	417	36	11.58	----	368	36	10.22	----	387	36	10.75	----
1802------------	3,373	138	24.44	----	3,141	138	22.76	----	3,339	138	24.20	----
1803------------	4,990	313	15.94	----	4,695	313	15.00	----	5,120	313	16.36	----
1804------------	658	13	50.62	----	663	13	51.00	----	752	13	57.85	----
1805------------	4,498	109	41.27	----	4,145	109	38.03	----	4,499	109	41.28	----
1806------------	15,180	246	61.71	----	15,010	246	61.02	----	16,941	246	68.87	----
1807------------	2,833	45	62.96	----	2,720	45	60.44	----	3,060	45	68.00	----
Alaska------------	9	4	2.25	0.0	9	4	2.25	0.0	9	4	2.25	0.0
1901------------	9	4	2.25	----	9	4	2.25	----	9	4	2.25	----
Hawaii------------	1,413	21	67.29	2.1	1,317	21	62.71	2.1	1,424	21	67.81	2.1
2001------------	268	9	29.78	----	250	9	27.78	----	270	9	30.00	----
2002------------	390	2	195.00	----	363	2	181.50	----	393	2	196.50	----
2003------------	210	6	35.00	----	196	6	32.67	----	212	6	35.33	----
2004------------	545	4	136.25	----	508	4	127.00	----	549	4	137.25	----
Caribbean---------	946	86	11.00	0.1	1,053	86	12.24	0.2	1,183	86	13.76	0.2
2101------------	946	86	11.00	----	1,053	86	12.24	----	1,183	86	13.76	----
2102------------	0	0	0	----	0	0	0	----	0	0	0	----
United States-----	666,152	58,586	11.37	100.0	626,099	58,586	10.69	100.0	679,560	58,586	11.60	100.0

Annual growth rate: 1975-1985: 0.6 percent decrease.
1985-2000: 0.6 percent increase.
1975-2000: 0.1 percent increase.

Source: USWRC, 1977.

Table 3E-3.--Flood damages in communities of more than 2,500

Aggregated subarea (ASA)	Absolute damage (thousands of 1967 dollars)			Communities with a flood problem	Dollars in damage per community	Type of community	
	1975	1985	2000	1975	(1975 dollars)	Urban 1/	Rural 2/
New England---------	18,784	24,111	33,799	498	60,707	--	--
101---------------	651	837	1,242	44	23,812	--	XO
102---------------	3,121	4,045	5,758	63	79,732	--	0
103---------------	4,931	6,296	8,787	237	33,486	YA	--
104---------------	5,302	6,770	9,353	47	181,561	--	--
105---------------	3,905	5,023	7,029	84	74,821	--	0
106---------------	274	368	550	23	19,174	--	0
Mid-Atlantic--------	20,597	26,442	37,293	870	38,104	--	--
201---------------	4,200	5,484	7,825	52	129,995	--	0
202---------------	1,115	1,392	1,877	271	6,622	YA	--
203---------------	3,154	4,027	5,649	232	21,880	--	--
204---------------	4,627	6,041	8,662	169	44,065	--	XO
205---------------	3,385	4,322	6,093	68	80,118	--	0
206---------------	4,116	5,176	7,187	78	84,938	--	0
South Atlantic-Gulf-	45,934	59,379	85,492	721	102,537	--	--
301---------------	13,022	16,877	24,612	87	20,415	--	0
302---------------	6,272	8,129	11,714	123	82,070	--	0
303---------------	2,785	3,636	5,289	75	59,765	--	XO
304---------------	11,641	15,087	21,582	131	143,021	--	0
305---------------	4,716	5,886	8,064	76	99,872	Y	0
306---------------	3,122	4,046	5,760	82	61,277	--	0
307---------------	2,890	3,773	5,540	67	69,423	--	0
308---------------	550	723	1,059	39	22,698	--	0
309---------------	936	1,222	1,824	41	36,743	--	0

Table 3E-3.--Flood damages in communities of more than 2,500--Continued

Aggregated subarea (ASA)	Absolute damage (thousands of 1967 dollars)			Communities with a flood problem	Dollars in damage per community	Type of community	
	1975	1985	2000	1975	(1975 dollars)	Urban 1/	Rural 2/
Great Lakes---------	3,151	4,051	5,709	747	6,789	--	--
401---------------	741	312	458	19	20,415	--	XO
402---------------	248	324	464	43	9,283	--	0
403---------------	30	38	53	225	215	YA	--
404---------------	325	421	597	99	5,284	--	0
405---------------	162	210	299	32	148	--	0
406---------------	1,555	1,985	2,771	155	16,147	--	--
407---------------	446	524	803	118	894	--	--
408---------------	114	187	264	56	4,139	--	0
Ohio---------------	13,412	12,445	25,703	658	32,806	--	--
501---------------	1,945	2,521	3,729	58	53,973	--	0
502---------------	4,753	6,160	8,812	298	25,670	Y	--
503---------------	3,028	3,924	5,559	100	48,735	--	--
504---------------	1,730	2,259	3,332	29	96,013	--	XO
505---------------	667	890	1,292	51	21,365	--	0
506---------------	422	547	782	89	7,631	--	0
507---------------	857	1,144	1,697	33	797	--	0
Tennessee----------	5,070	6,739	9,944	117	69,744	--	--
601---------------	2,338	3,120	4,608	61	61,687	Y	0
602---------------	2,732	3,619	5,336	56	78,519	--	XO
Upper Mississippi---	5,118	6,524	9,325	536	15,368	--	--
701---------------	393	506	704	121	227	--	0
702---------------	934	1,210	1,748	43	959	--	XO
703---------------	1,829	2,335	3,307	127	23,179	--	0
704---------------	1,624	2,153	3,043	116	23,226	--	0
705---------------	228	370	521	129	3,595	Y	0

Table 3E-3.--Flood damages in communities of more than 2,500--Continued

Aggregated subarea (ASA)	Absolute damage (thousands of 1967 dollars)			Communities with a flood problem	Dollars in damage per community	Type of community	
	1975	1985	2000	1975	(1975 dollars)	Urban 1/	Rural 2/
Lower Mississippi--	8,852	11,485	16,842	192	74,203	--	--
801--------------	7,776	10,078	14,767	54	231,763	--	0
802--------------	627	425	1,230	62	16,276	--	XO
803--------------	449	582	845	76	9,509	Y	0
Souris-Red-Rainy---	208	266	388	19	17,619	--	--
901--------------	208	266	388	19	17,619	--	XO
Missouri Basin-----	11,283	14,544	20,679	778	79,647	--	--
1001-------------	3	4	5	2	2,414	--	0
1002-------------	108	136	193	4	43,456	--	0
1003-------------	128	166	236	1	206,012	--	XO
1004-------------	644	816	1,171	15	69,100	--	0
1005-------------	107	135	195	12	14,351	--	0
1006-------------	102	130	188	19	8,640	--	0
1007-------------	993	1,249	1,743	38	42,058	--	0
1008-------------	360	456	651	20	28,970	--	0
1009-------------	692	897	1,271	30	37,125	--	0
1010-------------	132	169	240	37	5,742	--	0
1011-------------	8,014	10,386	14,786	50	257,965	Y	0
Arkansas-White-Red-	10,427	13,691	20,330	237	70,810	--	--
1101-------------	3,467	4,693	7,270	8	697,502	--	XO
1102-------------	847	1,073	1,547	20	68,161	--	0
1103-------------	1,102	1,386	1,964	43	41,247	--	0
1104-------------	4,547	5,937	8,676	70	104,546	Y	0
1105-------------	174	224	321	28	10,002	--	0
1106-------------	121	156	223	42	4,637	--	0
1107-------------	169	222	329	26	10,462	--	0

Table 3E-3.--Flood damages in communities of more than 2,500--Continued

Aggregated subarea (ASA)	Absolute damage (thousands of 1967 dollars)			Communities with a flood problem	Dollars in damage per community	Type of community	
	1975	1985	2000	1975	(1975 dollars)	Urban 1/	Rural 2/
Texas-Gulf----------	1,673	2,135	3,067	309	8,714	--	--
1201--------------	47	62	90	35	2,161	--	0
1202--------------	211	269	376	123	2,761	Y	0
1203--------------	1,040	1,328	1,919	61	27,440	--	0
1204--------------	286	362	517	35	13,152	--	XO
1205--------------	89	114	165	35	4,093	--	0
Rio Grande----------	4,355	5,564	8,049	60	116,820	--	--
1301--------------	27	34	49	1	43,456	--	0
1302--------------	2,645	3,377	4,880	22	193,502	--	0
1303--------------	47	59	84	10	7,564	--	XO
1304--------------	1,470	1,877	2,712	5	7,564	--	--
1305--------------	166	217	234	22	13,144	Y	0
Upper Colorado------	536	687	998	29	45,404	--	--
1401--------------	137	172	245	9	24,500	--	XO
1402--------------	188	240	349	7	43,226	Y	0
1403--------------	211	275	404	3	113,119	--	0
Lower Colorado------	24,487	30,793	42,573	62	635,661	--	--
1501--------------	2,708	3,666	5,388	7	622,633	--	XO
1502--------------	5,573	6,902	9,329	11	815,414	--	0
1503--------------	16,206	20,255	27,858	44	592,796	Y	0
Great Basin---------	1,489	1,892	2,673	52	46,086	--	--
1601--------------	693	891	1,272	42	26,556	Y	0
1602--------------	246	312	452	3	131,976	--	0
1603--------------	438	547	753	3	234,982	--	XO
1604--------------	112	142	196	4	45,065	--	0

Table 3E-3.--Flood damages in communities of more than 2,500--Continued

Aggregated subarea (ASA)	Absolute damage (thousands of 1967 dollars)			Communities with a flood problem	Dollars in damage per community	Type of community	
	1975	1985	2000	1975	(1975 dollars)	Urban 1/	Rural 2/
Pacific Northwest--	5,095	6,600	9,239	212	38,680	--	--
1701-------------	130	167	242	17	12,308	--	0
1702-------------	563	708	882	33	27,458	--	0
1703-------------	1,320	1,673	2,388	21	101,166	--	0
1704-------------	178	226	327	9	31,832	--	0
1705-------------	1,700	2,187	3,106	78	35,078	--	0
1706-------------	1,185	1,615	2,261	52	36,677	Y	0
1707-------------	19	24	33	2	15,290	--	XO
California---------	14,081	17,697	24,607	487	46,536	--	--
1801-------------	68	87	124	12	9,120	--	0
1802-------------	776	983	1,397	51	24,489	--	0
1803-------------	2,675	3,338	4,219	71	60,638	--	0
1804-------------	2,757	3,467	4,764	94	47,205	--	--
1805-------------	862	1,241	2,129	41	33,838	--	0
1806-------------	6,158	7,744	10,641	211	46,972	Y	--
1807-------------	785	1,002	1,434	17	74,319	--	XO
Alaska-------------	672	832	1,143	20	54,078	--	--
1901-------------	672	832	1,143	20	54,078	--	XO
Hawaii-------------	1,750	2,151	2,761	34	82,840	--	--
2001-------------	530	651	897	1	853,017	--	XO
2002-------------	330	406	558	3	177,041	--	0
2003-------------	720	885	1,218	29	39,959	YA	--
2004-------------	170	209	288	1	273,609	--	0

Table 3E-3.--Flood damages in communities of more than 2,500--Continued

Aggregated subarea (ASA)	Absolute damage (thousands of 1967 dollars)			Communities with a flood problem	Dollars in damage per community	Type of community	
	1975	1985	2000	1975	(1975 dollars)	Urban 1/	Rural 2/
Caribbean----------	484	643	979	72	10,819	--	--
2101-------------	440	587	896	67	10,263	Y	--
2102-------------	44	56	84	3	23,606	Y	--
United States------	197,458	253,721	361,593	6,150	51,675	--	--

1/ A "Y" indicates the most densely populated ASA in a region. An "A" indicates an ASA with a population density more than 15 times the population density of the United States as a whole.

2/ An "X" indicates the least densely populated ASA in a region. An "O" indicates an ASA with a population density less than 5 times the population density of the United States as a whole.

Source: Williams, 1979.

Table 3E-4.--"Other" upstream flood damages by aggregated subarea (ASA) for 1975 with projections for 1985 and 2000

(Modified central case, in 1967 dollars)

Aggregated subarea (ASA)	Damage (thousands of dollars)	Regional percent-age	Damage (thousands of dollars)	Regional percent-age	Damage (thousands of dollars)	Regional percent-age
	1975		1985		2000	
New England-----	4,706	2.3	5,947	2.3	8,512	2.3
101-----------	317	---	408	---	605	---
102-----------	547	---	709	---	1,009	---
103-----------	1,663	---	2,123	---	2,963	---
104-----------	739	---	944	---	1,304	---
105-----------	1,246	---	1,502	---	2,242	---
106-----------	194	---	261	---	389	---
Mid-Atlantic----	3,507	1.7	4,462	1.7	6,254	1.7
201-----------	193	---	252	---	360	---
202-----------	59	---	74	---	99	---
203-----------	279	---	356	---	500	---
204-----------	392	---	512	---	734	---
205-----------	928	---	1,185	---	1,670	---
206-----------	1,656	---	2,083	---	2,891	---
South Atlantic-Gulf-----------	61,129	30.5	79,383	30.7	115,395	31.0
301-----------	30,803	---	39,921	---	58,218	---
302-----------	12,104	---	15,687	---	22,659	---
303-----------	7,265	---	9,485	---	13,796	---
304-----------	2,761	---	3,578	---	5,119	---
305-----------	1,948	---	2,431	---	3,331	---
306-----------	739	---	958	---	1,363	---
307-----------	1,208	---	1,577	---	2,316	---
308-----------	1,380	---	1,815	---	2,658	---
309-----------	3,011	---	3,931	---	5,935	---
Great Lakes-----	670	0.3	861	0.3	1,210	0.3
401-----------	5	---	6	---	9	---
402-----------	57	---	74	---	107	---
403-----------	10	---	13	---	18	---
404-----------	119	---	154	---	218	---
405-----------	26	---	34	---	48	---
406-----------	361	---	461	---	643	---
407-----------	34	---	44	---	61	---
408-----------	58	---	75	---	106	---
Ohio------------	12,581	6.3	16,423	6.3	23,824	6.4
501-----------	1,746	---	2,263	---	3,347	---
502-----------	1,879	---	2,435	---	3,484	---
503-----------	1,034	---	1,340	---	1,898	---

Table 3E-4.--"Other" upstream flood damages by aggregated subarea (ASA) for 1975 with projections for 1985 and 2000--Continued

(Modified central case, in 1967 dollars)

Aggregated subarea (ASA)	Damage (thousands of dollars)	Regional percentage	Damage (thousands of dollars)	Regional percentage	Damage (thousands of dollars)	Regional percentage
	1975		1985		2000	
504-----------	1,099	---	1,435	---	2,117	---
505-----------	2,716	---	3,572	---	5,182	---
506----------	2,662	---	3,450	---	4,935	---
507----------	1,445	---	1,928	---	2,861	---
Tennessee------	8,042	4.0	10,689	4.1	15,773	4.2
601----------	3,670	---	4,897	---	7,234	---
602----------	4,372	---	5,792	---	8,539	---
Upper Mississippi---	17,859	8.9	22,957	8.9	32,519	8.7
701----------	2,272	---	2,923	---	4,069	---
702----------	3,303	---	4,281	---	6,183	---
703----------	5,114	---	6,530	---	9,251	---
704----------	5,033	---	6,474	---	9,150	---
705----------	2,137	---	2,749	---	3,866	---
Lower Mississippi----	14,824	7.4	19,323	7.5	28,512	7.6
801----------	8,879	---	11,507	---	16,861	---
802----------	5,774	---	7,594	---	11,329	---
803----------	171	---	222	---	322	---
Souris-Red-Rainy---------	2,650	1.3	3,384	1.3	4,937	1.3
901----------	2,650	---	3,384	---	4,937	---
Missouri-------	24,186	12.0	31,109	12.0	44,190	11.8
1001---------	52	---	64	---	92	---
1002---------	55	---	69	---	99	---
1003---------	58	---	75	---	107	---
1004---------	526	---	667	---	956	---
1005---------	1,137	---	1,430	---	2,067	---
1006---------	2,221	---	2,836	---	4,098	---
1007---------	1,769	---	2,225	---	3,105	---
1008---------	1,425	---	1,806	---	2,578	---
1009---------	1,899	---	2,461	---	3,487	---
1010---------	5,766	---	7,362	---	10,483	---
1011---------	9,278	---	2,024	---	17,118	---

Table 3E-4.--"Other" upstream flood damages by aggregated subarea (ASA) for 1975 with projections for 1985 and 2000--Continued

(Modified central case, in 1967 dollars)

Aggregated subarea (ASA)	Damage (thousands of dollars)	Regional percentage	Damage (thousands of dollars)	Regional percentage	Damage (thousands of dollars)	Regional percentage
	1975		1985		2000	
Arkansas-White-Red-----------	13,805	6.9	17,968	6.9	26,306	7.0
1101---------	1,713	---	2,319	---	3,592	---
1102---------	541	---	686	---	988	---
1103---------	2,172	---	2,732	---	3,871	---
1104---------	6,139	---	8,015	---	11,713	---
1105---------	831	---	1,069	---	1,153	---
1106---------	750	---	965	---	1,384	---
1107---------	1,659	---	2,182	---	3,225	---
Texas-Gulf-----	5,458	2.7	6,981	2.7	9,995	2.7
1201---------	550	---	723	---	1,054	---
1202---------	1,450	---	1,851	---	2,584	---
1203---------	1,956	---	2,497	---	3,609	---
1204---------	823	---	1,043	---	1,489	---
1205---------	679	---	867	---	1,259	---
Rio Grande-----	1,611	0.8	2,053	0.8	2,975	0.8
1301---------	140	---	175	---	255	---
1302---------	618	---	789	---	1,140	---
1303---------	224	---	280	---	399	---
1304---------	439	---	561	---	810	---
1305---------	190	---	248	---	371	---
Upper Colorado-	533	0.3	680	0.3	984	0.3
1401---------	196	---	246	---	351	---
1402---------	207	---	264	---	384	---
1403---------	130	---	170	---	249	---
Lower Colorado-	7,366	3.7	9,204	3.5	12,664	3.4
1501---------	223	---	302	---	444	---
1502---------	1,317	---	1,631	---	2,205	---
1503---------	5,826	---	7,271	---	10,015	---
Great Basin----	1,002	0.5	1,267	0.5	1,780	0.5
1601---------	271	---	349	---	498	---
1602---------	185	---	234	---	340	---
1603---------	428	---	534	---	736	---
1604---------	118	---	150	---	206	---
Pacific Northwest-----	5,858	2.9	7,582	2.9	10,533	2.8
1701---------	262	---	337	---	488	---

Table 3E-4.--"Other" upstream flood damages by aggregated subarea (ASA) for 1975 with projections for 1985 and 2000--Continued

(Modified central case, in 1967 dollars)

Aggregated subarea (ASA)	Damage (thousands of dollars)	Regional percent-age	Damage (thousands of dollars)	Regional percent-age	Damage (thousands of dollars)	Regional percent-age
	1975		1985		2000	
1702---------	1,044	---	1,313	---	1,635	---
1703---------	1,410	---	1,787	---	2,551	---
1704---------	526	---	667	---	966	---
1705---------	927	---	1,192	---	1,694	---
1706---------	1,544	---	2,105	---	2,946	---
1707---------	145	---	181	---	253	---
California----	14,275	7.1	18,022	7.0	25,487	6.8
1801--------	4,129	---	5,272	---	7,544	---
1802--------	2,712	---	3,437	---	4,888	---
1803--------	4,130	---	5,154	---	7,285	---
1804--------	2	---	3	---	3	---
1805--------	527	---	658	---	934	---
1806--------	2,331	---	2,931	---	4,028	---
1807--------	444	---	567	---	811	---
Alaska--------	54	0.0	67	0.0	92	0.0
1901--------	54	---	67	---	92	---
Hawaii--------	9	0.0	11	0.0	15	0.0
2001--------	0	---	0	---	0	---
2002--------	0	---	0	---	0	---
2003--------	9	---	11	---	15	---
2004--------	0	---	0	---	0	---
Caribbean-----	335	0.2	447	0.2	681	0.2
2101--------	335	---	447	---	681	---
2102--------	0	---	0	---	0	---
United States-	200,460	100.0	258,730	100.0	372,638	100.0

Annual growth rate: 1975 to 1985: 2.13 percent.
1985 to 2000: 2.46 percent.
1975 to 2000: 2.33 percent.

Source: USWRC, 1977.

Figure 3E-1.--Aggregated subareas (ASA's) where flood damages on cropland and pasture are high. (Williams, 1979)

Figure 3E-2.--Aggregated subareas (ASA's) where flood damages in urban areas are high. (Williams, 1979)

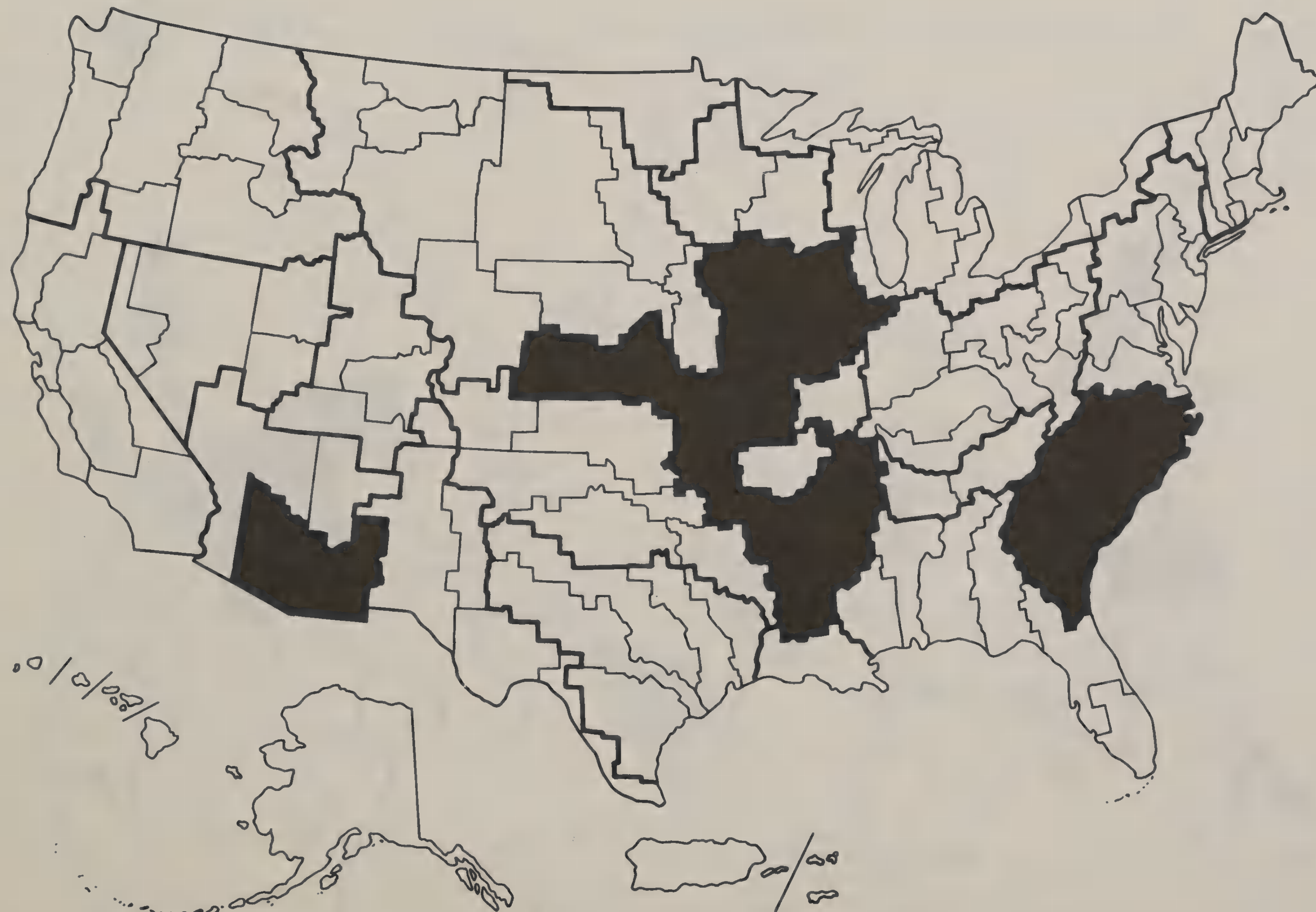


Figure 3E-3.--Aggregated subareas (ASA's) where flood damages on "other" land are high. (Williams, 1979)

The Water Resources Council (1977) expressed the magnitude of the upstream and downstream flood problem in terms of--

1. average annual flood damages per square mile (fig. 3E-4).
2. average annual flood damages per capita (fig. 3E-5).
   If flood damages were evenly distributed over the entire population, current flood damages in the United States would average \$10.50 per person per year. If damages were distributed over local populations, they would exceed \$20 per person in 34 ASA's and \$50 per person in 8.
3. average annual flood damages relative to earnings (fig. 3E-6). Current flood losses equal 0.33 percent of the Nation's earnings. They exceed 1 percent of the ASA earnings in 21 ASA's and exceed 2 percent in 12 ASA's.
4. damage per acre of cropland the flood plain (fig. 3E-7).
5. monetary flood losses by ASA (fig. 3E-8).

Scope

Upstream flood damages are primarily defined by the annual dollar damage to cropland, pasture, urban land, and other property. In ASA's throughout the country, significant damage occurs on all categories of property, but the levels of losses vary. USDA should direct its program to reduce upstream flood damages toward the full range of damages. Limiting the scope of a program to one type of damage would preclude an open, balanced look at all possible solutions.

Focus

The RCA analysis has examined three approaches to the problem of upstream flood damages--broad, target, and shotgun.

Using the broad approach, USDA would attempt to respond to flood damages equally throughout the country, regardless of the magnitude of the problem or its relationship to other potential problem areas. USDA does not consider this approach to be the most efficient.

Using the target approach, USDA would focus on the most severe problems in selected areas. The Department would consider complementary and competitive features of programs directed at the other potential problem areas.

The shotgun approach is a combination of the broad and target approaches. USDA would focus on one problem element, such as cropland and pasture flood damage, and attempt to solve that problem throughout the country. Using this approach, USDA could not effectively respond to the full range of upstream flood damages.

Using data from the flood damages tables (tables 3E-2, 3E-3, and 3E-4), per capita income data, and data from the consultant, USDA developed a point system to rank ASA's according to the severity of flooding problems. In addition to selecting high damage ASA's, USDA gave priority to areas where per capita incomes were low and to areas where opportunities existed to improve the environment. It also considered multiple purpose needs in the target areas. Of the 106 ASA's, 27 were ranked high in flood damages, 39

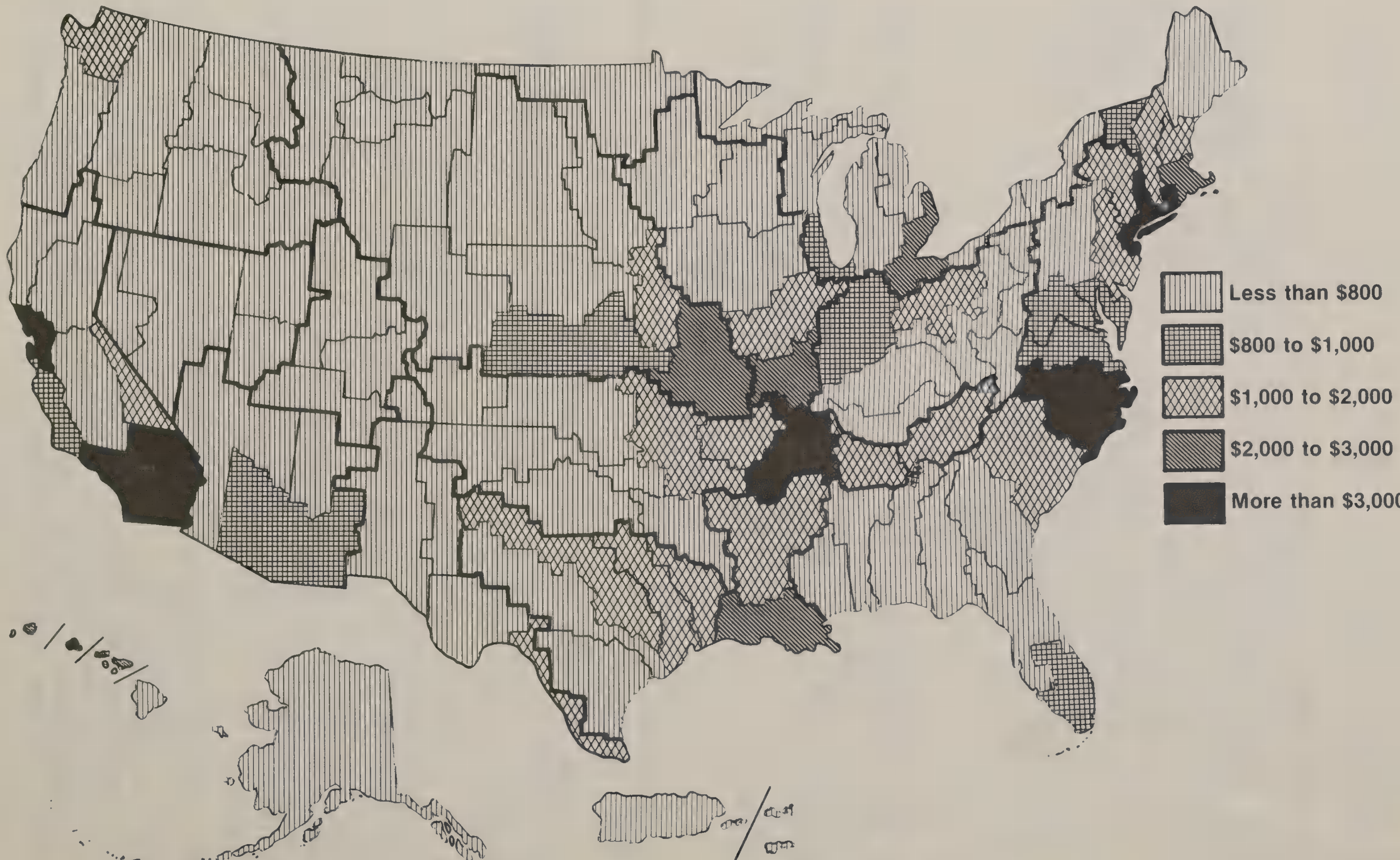


Figure 3E-4.--Average annual flood damages per square mile, by ASA (1967 dollars). (USWRC, 1977)

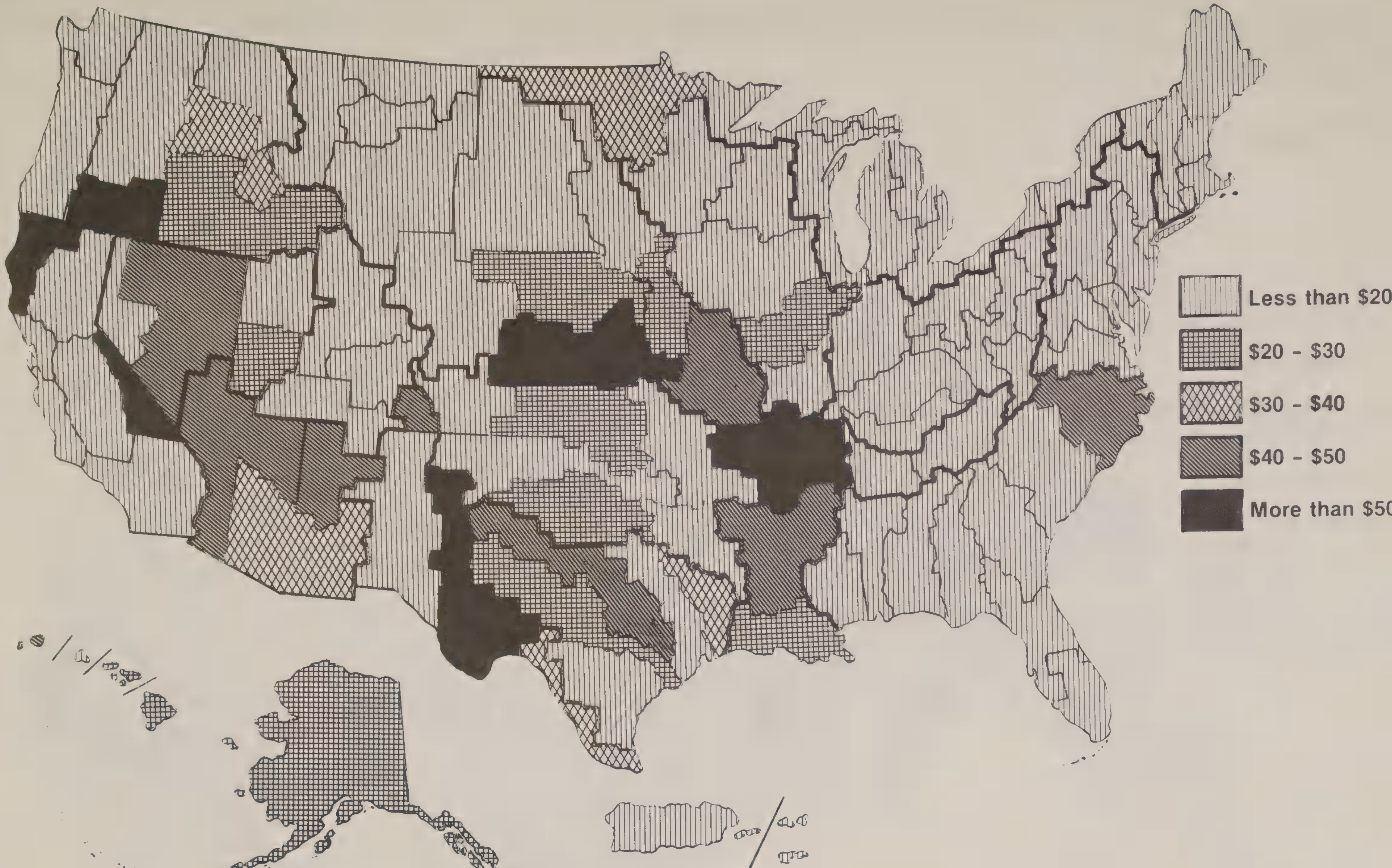


Figure 3E-5.--Average annual flood damages per capita, by ASA (1967 dollars). (USWRC, 1977)

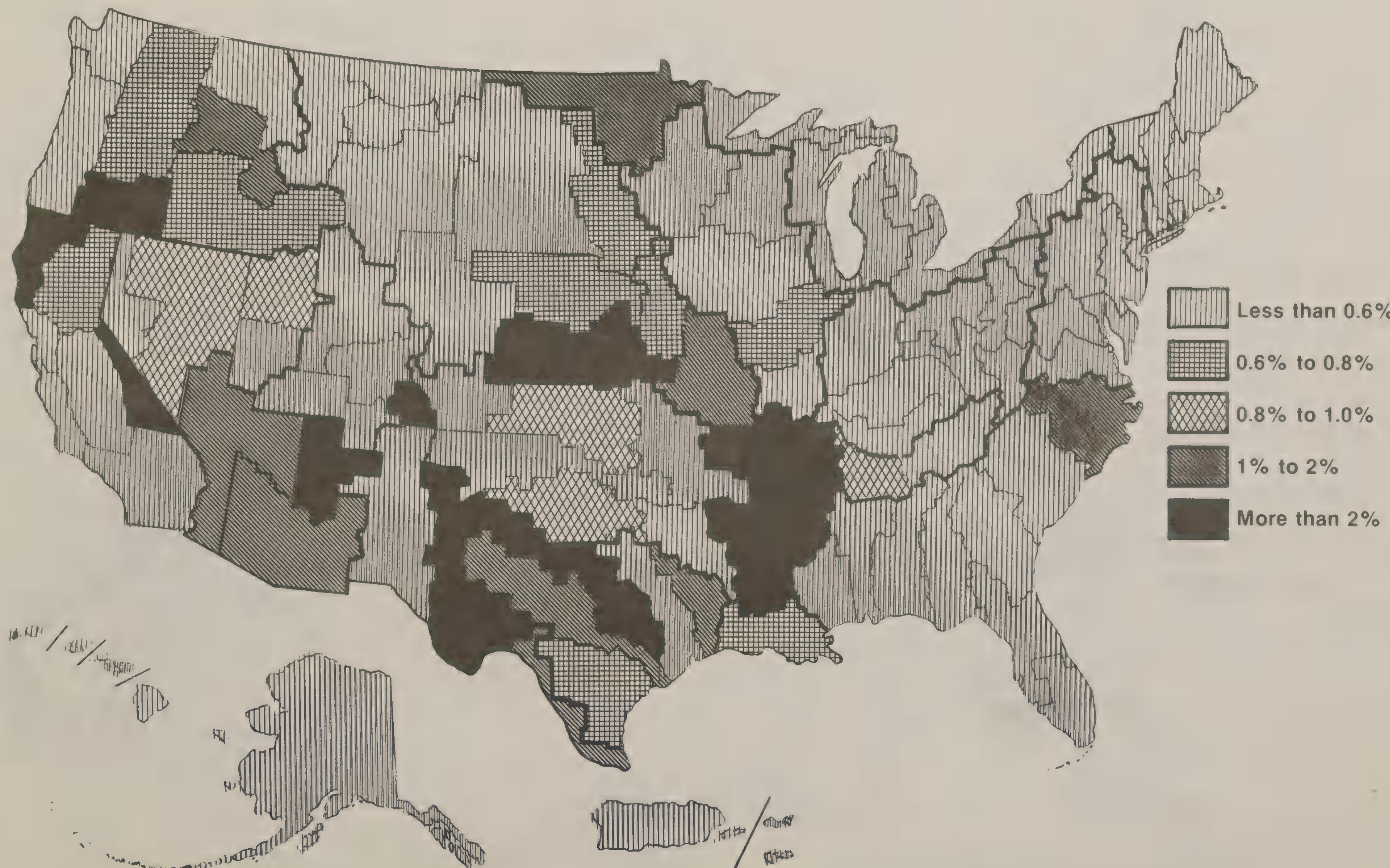


Figure 3E-6.--Average annual flood damages as a percentage of earnings, by ASA. (USWRC, 1977)

Figure 3E-7.--Average annual flood damages per acre of cropland on flood plains, by subarea (1967 dollars). (USWRC, 1977)

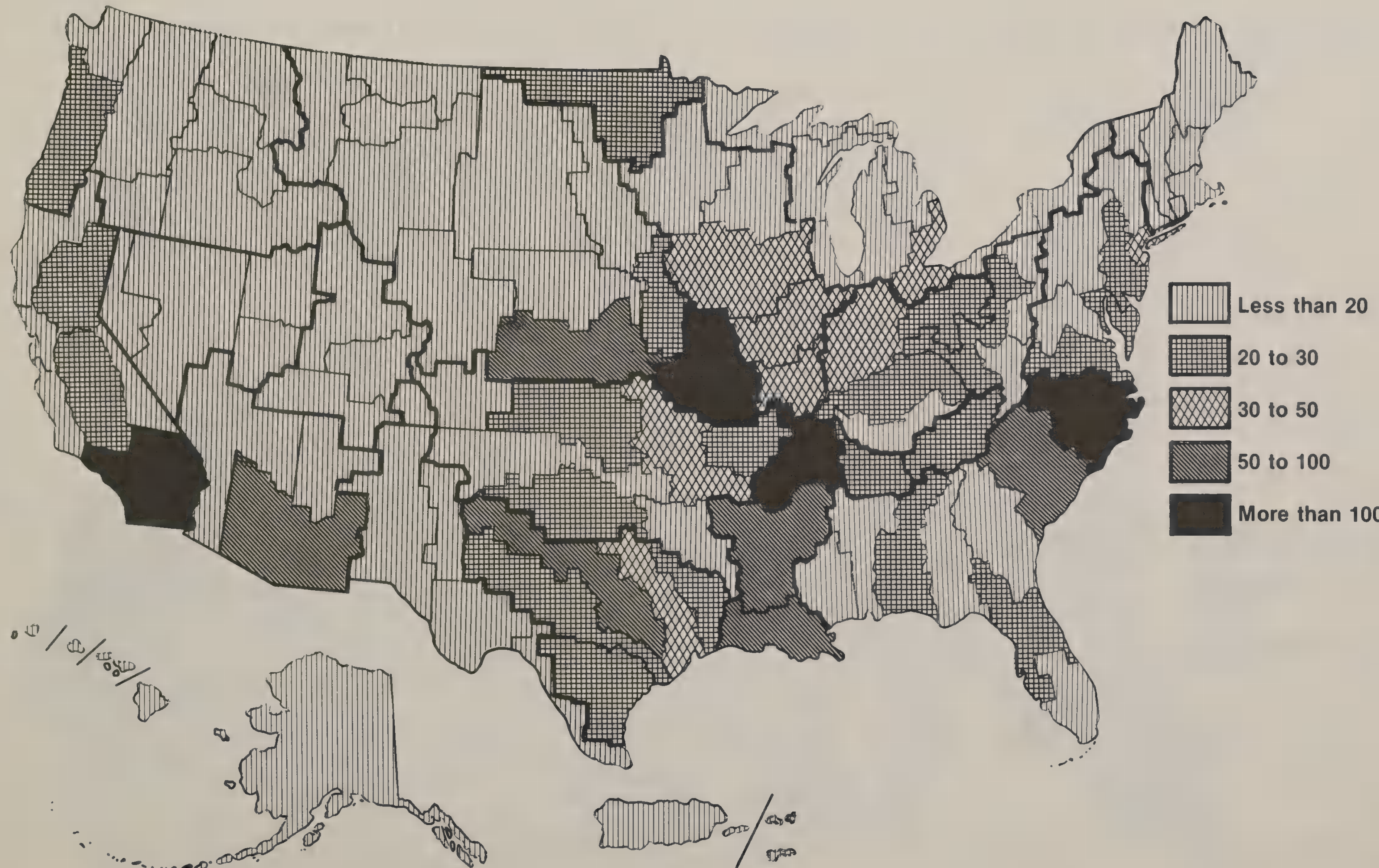


Figure 3E-8.--Average annual flood damages, by ASA (millions of 1967 dollars). (USWRC, 1977)

medium, and 40 low (see tables 3E-5, 3E-6, and 3E-7). USDA would implement few projects in the 40 ASA's ranked low. It would concentrate resources for planning and implementing flood-prevention programs where ASA's are ranked high or medium, flood problems are most severe, and needs defined in other potential problem areas could also be met.

Alternative Objective Levels

Economic and environmental considerations make it impossible to eliminate flood damages. White and Haas (1977) indicate that "it should be possible to reduce annual losses by at least 20 percent if the economically feasible works could be built rapidly and cheaply enough," and that "it seems possible that as much as 25 to 35 percent of mean annual losses could be reduced over a period of 20 years by a combination of measures other than construction of protection works."

In light of these findings, USDA developed objective levels for control of upstream flood damages.

Objective level 1.--USDA would attempt to reduce total upstream flood damages by 16 percent through programs designed to reduce damages by 20 percent in high damage ASA's, 12 percent in medium damage ASA's, and 5 percent in low damage ASA's.

Objective level 2.--USDA would attempt to reduce total upstream flood damages by 9 percent through programs designed to reduce damages by 10 percent in high damage ASA's, 9 percent in medium damage ASA's, and 4 percent in low damage ASA's.

Objective level 3.--USDA would attempt to reduce total upstream flood damages by 5 percent through programs designed to reduce damages by 7 percent in high damage ASA's and 3 percent in medium damage ASA's, and by making no change in low damage ASA's.

Recommendations for Future Analysis

In the future, USDA should make a complete, integrated numerical analysis of all information relating to upstream flood damages. This analysis should define the problem, review constraints and opportunities for action, consider possible solutions, and display the results. Results of flood hazard studies, flood insurance, river basin reports, and watershed plans should be put in a data base and analyzed statistically. USDA should also analyze the location of wetlands, the per capita income of flood plain landowners in each ASA, and the acreage of prime farmlands in flood plains in each ASA. It should identify locations where a flood control program would help to meet other needs, such as improving water quality or fish and wildlife habitat. The Department should also determine the cost and effectiveness of structural flood control measures and land treatment and of various approaches to flood plain regulation--such as zoning, land acquisition, and education. It should consider factors such as local acceptance, dollar benefits, energy requirements, and the potential increase or decrease in erosion.

Table 3E-5.--Areas having low flood damages

Aggregated subarea (ASA)	Acres	Damages to cropland and pasture	Dollars per acre	Urban damages	Other damages	Per capita income
403-------------	25	156	6.24	30	10	7,395
405-------------	102	408	4.00	162	26	6,072
1001-------------	160	128	0.80	3	52	5,914
1002-------------	210	170	0.80	108	55	5,916
1003-------------	93	114	1.22	128	58	5,844
1401-------------	146	169	1.15	137	196	5,519
1402-------------	140	239	1.70	188	207	5,103
1901-------------	4	9	2.25	672	54	7,555
401-------------	54	81	1.50	741	5	5,123
1005-------------	1,004	1,018	1.01	107	1,137	5,252
1102-------------	150	433	2.88	847	541	5,618
1301-------------	47	168	3.57	27	140	6,137
1403-------------	62	223	3.59	211	130	4,544
1603-------------	25	187	7.48	438	428	6,429
1707-------------	119	816	6.85	19	145	6,103
2102-------------	---	---	0.00	44	---	---
1004-------------	220	605	2.75	644	526	5,572
1007-------------	436	2,771	6.35	993	1,769	6,428
106-------------	45	390	8.66	274	194	5,381
203-------------	373	1,589	4.26	3,154	279	6,567
408-------------	85	923	10.85	114	58	6,331
701-------------	540	3,253	6.02	393	2,272	6,488
1303-------------	30	302	10.06	47	224	5,579
104-------------	18	51	2.83	5,302	739	7,073
105-------------	36	217	6.02	3,905	1,246	6,797
202-------------	13	97	7.46	1,115	59	8,125
305-------------	1,109	5,862	5.28	4,716	1,948	6,486
702-------------	330	1,960	5.93	934	3,303	5,258
803-------------	8,546	11,855	1.38	449	171	5,132
1006-------------	721	3,473	4.81	102	2,221	5,128
1008-------------	616	5,547	9.00	360	1,425	6,006
1107-------------	1,545	8,064	5.21	169	1,659	4,611
1201-------------	236	2,205	9.34	47	550	5,019
1204-------------	172	1,756	10.20	286	823	5,439
1302-------------	377	2,847	7.55	2,645	618	5,114
1801-------------	36	417	11.58	68	4,129	5,657
204-------------	101	425	4.20	4,627	392	5,689
407-------------	32	526	16.43	446	34	6,627
504-------------	61	213	3.49	1,730	1,099	4,616
901-------------	1,275	7,131	5.59	208	2,650	5,001

Table 3E-6.--Areas having medium flood damages

Aggregated subarea (ASA)	Acres	Damages to cropland and pasture	Dollars per acre	Urban damages	Other damages	Per capita income
101--------	11	146	13.27	651	317	5,093
308--------	663	5,838	8.80	550	1,380	4,694
404--------	134	1,974	14.73	325	119	5,968
1009--------	901	7,239	8.03	692	1,899	6,002
1105--------	1,172	10,525	8.98	174	831	5,614
1501--------	45	178	3.95	2,708	223	3,056
1502--------	193	1,073	5.55	5,573	1,317	6,376
1604--------	2	74	37.00	112	118	7,000
1701--------	102	1,445	14.16	130	262	5,445
2101--------	86	946	11.00	440	335	1,178
102--------	30	300	10.00	3,121	547	5,858
205--------	1,243	11,980	9.63	3,385	928	6,042
206--------	206	2,593	12.58	4,116	1,656	7,187
306--------	412	4,296	10.42	3,122	739	5,675
307--------	454	4,680	10.30	2,890	1,208	4,597
503--------	408	4,629	11.34	3,028	1,034	5,983
1602--------	3	97	32.33	246	185	4,676
1705--------	417	4,743	11.37	1,700	927	5,855
103--------	29	496	17.10	4,931	1,663	6,860
406--------	327	5,653	17.28	1,555	361	6,971
501--------	76	633	8.32	1,945	1,746	5,030
505--------	776	7,357	9.48	677	2,716	5,195
705--------	480	7,294	15.19	288	2,137	6,327
1106--------	1,229	15,910	12.94	121	750	5,468
1304--------	106	1,485	14.00	1,470	439	4,861
1601--------	11	261	23.72	693	271	5,364
201--------	34	692	20.35	4,200	193	6,101
303--------	527	6,209	11.78	2,785	7,265	4,742
402--------	22	886	40.27	248	57	5,388
703--------	1,800	15,230	8.46	1,829	5,114	6,173
802--------	6,728	52,233	7.76	627	5,774	4,157
1202--------	196	7,655	39.05	211	1,450	6,391
1205--------	119	4,329	36.37	89	679	5,070
1704--------	122	3,598	29.49	178	526	5,260
1803--------	313	4,990	15.94	2,675	4,130	6,043
2001--------	9	268	29.77	530	---	---
2002--------	2	390	195.00	330	---	---
2003--------	6	210	35.00	720	9	---
2004--------	4	545	136.25	170	---	---

Table 3E-7.--Areas having high flood damages

Aggregated subarea (ASA)	Acres	Damages to cropland and pasture	Dollars per acre	Urban damages	Other damages	Per capita income
304--------	328	2,984	9.09	11,641	2,761	5,456
309--------	309	4,962	16.05	936	3,011	4,415
502--------	185	2,339	12.64	4,753	1,879	5,970
506--------	571	12,127	21.23	422	2,662	5,873
1010--------	1,140	15,251	13.37	132	5,766	5,893
1103--------	876	11,928	13.61	1,102	2,172	6,065
1203--------	387	7,082	18.29	1,040	1,956	5,277
1503--------	910	5,954	6.54	16,206	5,826	5,824
1702--------	248	5,742	23.15	563	1,044	5,844
1703--------	362	7,595	20.98	1,320	1,410	5,641
1805--------	109	4,498	41.26	862	527	6,262
1807--------	45	2,833	62.95	785	444	5,660
507--------	122	5,681	46.56	857	1,445	4,676
602--------	454	7,911	17.42	2,732	4,372	4,579
1101--------	550	7,900	14.36	3,467	1,713	3,604
1305--------	272	9,951	36.58	166	190	3,840
1706--------	277	8,394	30.30	1,185	1,544	6,278
1802--------	138	3,373	24.44	776	2,712	5,836
704--------	1,000	20,425	20.42	1,624	5,033	6,330
1804--------	13	658	50.61	2,757	2	7,665
601--------	308	7,756	25.18	2,338	3,670	4,535
1104--------	1,690	21,312	12.61	4,547	6,139	5,031
302--------	2,483	33,566	13.51	6,272	12,104	5,140
801--------	3,285	49,803	15.16	7,776	8,879	4,910
1806--------	246	15,180	61.70	6,158	2,331	7,044
1011--------	1,565	43,416	27.74	8,014	9,278	5,930
301--------	1,981	83,583	42.19	13,022	30,803	4,904

References

Federal Emergency Management Agency, Federal Insurance Administration. 1968-1979. Flood insurance reports (various).

United States Department of Agriculture, Soil Conservation Service. 1956-1979. Watershed work plans (various).

United States Department of Agriculture, Soil Conservation Service. 1978. 1977 National resource inventories.

United States Department of Commerce, Bureau of the Census. 1977. County and city data book 1977.

United States Water Resources Council. 1970. Water resource regions and subregions for the national assessment of water and related land resources.

United States Water Resources Council. 1974. 1972 OBERS projections: Regional economic activity in the United States. Series E, Population, Vol. 1. Concepts, methodology, and summary data.

United States Water Resources Council. 1977. Estimated flood damages. Appendix B: Nationwide analysis report.

United States Water Resources Council. 1978a. The Nation's water resources, 1975-2000. Second Natl. Water Assess., Stat. Append. Vol. A-1. (Draft)

United States Water Resources Council. 1978b. The Nation's water resources, 1975-2000: Functional uses. Second Natl. Water Assess., Part III. (Draft)

White, Gilbert F., and J. Eugene Haas. 1977. Assessment of research on natural hazards. MIT Press, Cambridge, Mass.

Williams, Charles, Inc. 1979. Upstream flood damages. (Unpublished)

Section F-Potential Problem Area 6, Energy Conservation and Production

Problem Statement

The current shortage of energy and the likelihood of continued shortages and increased prices clearly underscore the need for frugal use of energy on farms and ranches. Although farms use only 2.9 percent of the energy consumed in the United States, the potential savings on farms are still substantial. Tables 3F-1 and 3F-2 show patterns of energy use in American agriculture.

Energy conservation is inextricably related to soil and water conservation. Erosion lowers the productivity of land and impairs the quality of water. As soil productivity declines, the energy needed for each unit of production increases. A great deal of energy is required to improve the quality of water impaired by erosion. Nonfarm developments on prime farmland cause farmers to use less productive land, which requires more energy. Biomass production will likely occur on marginal lands that are more subject to erosion.

Centuries of good management may be required to restore the productivity of severely eroded soils to their original levels. Once some soils are eroded, their original productivity can never be restored. Thus, erosion can be viewed as an energy tariff on future generations who may be less able to pay than we are today.

The structure and scale of agriculture in the future must be considered. Agriculture is a dynamic system that adjusts continuously to circumstances. In the future energy costs will be higher. Higher costs will cause adjustments in agriculture and in the end will probably increase prices of food and other farm products. To help us adapt to the future, we need to know where the effects of higher energy costs and shortages will be most severe, where more readily available forms of energy can be substituted, where energy can be saved, and what adjustments can be made in response to increasing prices and decreasing supplies of energy from present sources.

USDA has set an energy goal of net self-sufficiency in agriculture by 1990. The assumptions used in the analysis are based on very limited information. In the early stages of addressing this problem, therefore, it may be desirable to initiate trial projects only. Should the goal be modified, the annual investments required would be altered accordingly. The USDA goal of net self-sufficiency requires further explanation. By energy self-sufficiency, the Department means that the total energy used in agricultural production on the Nation's farms and ranches will be equivalent to the total energy produced in agriculture. The Department also considered the alternative of achieving self-sufficiency on each individual farm but does not consider this a practical objective for every farm although for many farms it will be possible.

In determining the level of energy generation and conservation required to make agriculture self-sufficient, USDA estimated the potential energy that could be generated using grains, crop or plant residue, or other organic sources (in excess of domestic or export demand levels) and alternative sources, such as the sun, wind, and water. The energy equivalents of agricultural commodities produced and processed for food and nonenergy fiber

Table 3F-1.--Agricultural energy use by region, as a percentage of total Btu's from different types of fuel, 1976

Region	Fuel: Gasoline	Diesel fuel and fuel oil	LP gas	Natural gas	Coal	Electricity	Percentage of U.S. total
	(Percentage of total Btu's)						
Northeast--------	54.0	29.0	7.0	0.5	(1/)	9.0	4.4
Lake States------	58.0	26.4	8.7	(1/)	(1/)	6.7	9.6
Corn Belt--------	50.1	29.8	15.8	(1/)	(1/)	4.2	19.7
Northern Plains--	30.3	41.7	10.5	14.0	(1/)	3.5	15.5
Appalachian------	33.7	39.1	22.5	0.2	0.5	4.4	6.6
Southeast--------	26.5	56.3	12.5	0.6	0.2	3.8	7.2
Delta States-----	26.4	51.6	15.8	3.0	0	3.2	5.2
Southern Plains--	22.0	20.6	9.2	43.6	0	4.7	13.8
Mountain---------	23.8	23.5	3.3	31.4	(1/)	17.9	9.4
Pacific----------	23.2	36.5	2.9	2.7	(1/)	34.7	8.6
United States--	35.3	33.7	10.9	11.6	(1/)	8.4	100.0

1/ = Insignificant.
Source: (Van Dyne et al., 1979).

Table 3F-2.--Amounts of energy used in agriculture, 1978

Sector	Fuel: Gasoline	Diesel fuel	Fuel oil	LP gas	Natural gas	Coal	Electricity	Total Btu's
	(Million gallons)				(Billion cu ft)	(Thousand short tons)	(Billion kwh)	(Quadrillion)
Agricultural inputs 1/--	3,527	2,706	271	(2/)	728.5	150	13.5	0.8
Agricultural production: 3/								
Crops-----	2,833	2,327	286	1,017	134.9	(2/)	21.9	1.0
Livestock-	582	347	10	382	4.9	34.6	9.8	.2

1/ Includes farm machinery, livestock feed, fertilizers, and pesticides.
2/ Insignificant amounts.
3/ Includes energy used directly for agricultural production.
Source: (Van Dyne et al., 1979).

were excluded. The energy that could be purchased with the money generated by exported agricultural commodities was also excluded.

Scope

USDA limited the scope of RCA activities dealing with energy to conservation of energy used on farms and ranches and to the generation of energy from biomass or other resources on farms and ranches. The effects that production of biomass for either farm or nonfarm use has on soil and water conservation were analyzed.

Other agriculture-related energy uses not within the scope of RCA analysis are off-farm energy uses (that is, energy use not related to soil, water, and related resources, for example, in the agricultural industries) and energy used by USDA in carrying out its mission.

Focus

USDA reviewed a number of data sources to determine current energy uses in agriculture and compared the opportunities to save or produce energy to the existing patterns of use in order to determine potential energy conservation.

USDA chose to emphasize minimizing energy use per unit of production because total energy use is closely tied to total production. Energy use in agriculture probably cannot be reduced, on an absolute basis, because production will probably increase in the future. Energy can be used more efficiently in agricultural production, however. Emphasizing energy use per unit of production will permit USDA to analyze alternatives and identify complementary measures.

USDA decided to consider both energy generation and energy substitution. It chose the following areas as appropriately a part of or related to the management and conservation of soil, water, and related resources.

A. Areas affecting energy savings:
   1. Conservation tillage
   2. Crop drying techniques
   3. Fertilizer use
   4. Soil erosion
   5. Prime farmland
   6. Agricultural water management
   7. Management of pasture and range
   8. Shelterbelts and windbreaks

B. Areas affecting energy generation and substitution:
   1. Organic wastes as fertilizers
   2. Biomass as an energy source
   3. Alternative energy sources on the farm
   4. Legumes as a source of fertilizer
   5. Methane from manures

Table 3F-3 shows USDA estimates of maximum possible energy savings and maximum possible energy generation and substitution for each of these areas, in addition to those practices already being used. The amounts shown in the

table do not represent net energy savings since they do not account for energy expended in obtaining the desired level of energy savings or energy generation. The technology needed to obtain these results has not been fully developed for several of these areas. It is possible that for some areas, energy savings or energy generation will not be economical. USDA programs, however, will continue to address these areas.

Substitution of coal for imported fuels will probably be an important part of a program for national energy self-sufficiency. Surface mining of coal removes land from agricultural production and causes soil and water conservation problems in most affected areas. Effects and needs for conservation programs are discussed in the RCA Appraisal 1980, Review Draft, Part I, chapter 3.

Table 3F-3.--Estimated maximum possible energy savings and maximum possible energy generation and substitution, per year

Area	Maximum possible savings or generation
	(Trillion Btu's)
Energy savings:	
Conservation tillage	58
Crop drying techniques	19
Fertilizer use	51
Soil erosion	113
Prime farmland	78
Agricultural water management	73
Management of pasture and range	7
Shelterbelts and windbreaks	31
Total potential energy savings	428
Energy generation and substitution:	
Organic wastes as fertilizer	84
Biomass as an energy source	10,464
Legumes as a source of fertilizer	62
Methane from manures	68
Total potential energy generation	10,678
Total energy used on farms and ranches	2,320
Total energy used in Nation	80,000

Opportunities for Energy Conservation in Agriculture

There are potential energy savings in a number of areas in agriculture. The discussion of each area describes ways to save energy and estimates how much energy could be saved.

Conservation Tillage.--Conservation tillage retains protective crop residue on the soil throughout the year. Conservation tillage methods include no-till, strip tillage, stubble mulching, and other types of minimum tillage. USDA reports indicate that about 52 million acres are now farmed under conservation tillage.

USDA has established that applying conservation tillage on 40 percent of the cropland in the Nation is a reasonable goal. Research shows that conservation tillage can save the equivalent of 2.5 to 3 gallons of diesel fuel for each acre tilled (CAST, 1977; SCSA, 1977). Applying conservation tillage on 40 percent of the 413 million acres of cropland in the Nation would save 413 million gallons of diesel fuel annually, or about 58 trillion Btu's per year.

USDA projections indicate that there will be 432 million acres of cropland in the United States by 2030. If 40 percent of that land were farmed under conservation tillage, 302 million gallons of fuel could be saved annually in addition to that saved by existing conservation tillage. Because there may be some environmental risks which would be incurred at this level of conservation tillage, it should not be assumed that this potential will be achieved. Additional data on the topic is presented in the analysis for Potential Problem Area 1, Food and Fiber Production.

Crop Drying Techniques.--Crop production technology has not necessarily been concerned with energy costs or efficiency. Faced with recent rapid increases in energy prices and with threats of shortage, farmers now have an incentive to alter production technology to save energy.

Crop drying requires large amounts of gas or petroleum. The equivalent of about 1 billion gallons of liquefied petroleum (LP) gas is used annually to dry tobacco, corn, and rice. In some cases the energy expended in drying corn exceeds the total energy used in preparing the seedbed, planting, cultivating, and harvesting.

Crop drying, since it uses primarily heat and an air movement or ventilation technique, can employ alternative energy sources, some of which can be generated on the farm. USDA estimates that 20 percent of the energy now used to dry crops could be saved. The annual savings would be equivalent to about 200 million gallons of LP gas, or about 19 trillion Btu's. To achieve this goal by 1990, nearly 480,000 drying units would need to be converted. Total annual costs of achieving this goal are estimated at nearly $60 million. The cost would include investments in research, field trials, information and education, grants and loans, and private investments.

Fertilizer Use.--Because fertilizers have been cheap, some farmers have used more fertilizer than necessary. Increased fertilizer prices have reduced such waste, but many farmers still use commercial fertilizer in excess of plant requirements.

A University of Nebraska study (1979) shows that many farmers commonly apply fertilizer at rates higher than those recommended by commercial laboratories. Fifty million acres of cropland are overfertilized; 3.3 billion pounds of fertilizer are used unnecessarily on cropland annually. About 102 trillion Btu's are used to produce this extra fertilizer each year. USDA estimates that education and information can help farmers save about half of this total, or about 51 trillion Btu's per year. Saving this much fertilizer by 1990 would produce a net saving of $330 million annually, based on a cost estimate of 20 cents per pound.

Soil Erosion.--Most eroded soils yield less than their uneroded equivalents. Plows and other tillage equipment are harder to pull through eroded soils than through uneroded soils. The differences in yields and energy needed for tillage caused by soil erosion are highly variable. Some severely eroded soils will yield only half as much as they would if they were not eroded. Studies in Iowa indicate that severely eroded soils require from 10 to 80 percent more energy for tillage than do similar uneroded soils (USDA, 1979c).

Erosion control eases tillage and improves yields. It also minimizes the loss of plant nutrients through soil erosion; such losses average almost $6 per ton of topsoil lost.

Estimates of yield reduction caused by soil erosion vary from about 1 to 3 bushels of corn per acre for each inch of topsoil lost (Van Doren and Bartelli, 1956) to 6 bushels per acre (Lyles, 1975), depending on the nature of the soil. Assuming a median reduction of 4 bushels per acre and complete erosion of a surface layer 12 inches thick, the production loss would be 48 bushels per acre. If energy requirements increase 50 percent as a result of erosion and the original yield was 144 bushels, then energy use per unit of production would increase about 2¼ times. In the soil used in this example, the subsoil is distinctly less favorable for plant growth than the surface soil. In tests in Iowa on a soil called Marshall silt loam, which has a very favorable subsoil for plant growth, the researchers sustained yield levels after the surface horizon was removed only by adding 50 pounds more nitrogen per acre (Engelstad and Shrader, 1961).

One ton of topsoil contains about 3 pounds of nitrogen, 2.4 pounds of phosphorus, and 44 pounds of potassium (Willis and Evans, 1977). About 283,000 Btu's are required to manufacture commercial fertilizer having the same amount of nutrients. Since about 2 billion tons of soil are lost each year through erosion, about 566 trillion Btu's are lost with the soil. USDA has established as a goal reducing erosion by one-fifth. Reducing erosion by one-fifth would save an estimated 113 trillion Btu's per year.

Prime Farmland.--Prime farmland is the land best suited to agricultural production. The National Resource Inventories (USDA, 1978b) showed 346 million acres of prime farmland in the United States. Of this total, 116 million acres, or about one-third, are used for pasture, forest, and other purposes besides crop production. USDA estimates that each year about 1 million acres of prime farmland are converted to nonfarm uses, mostly urban uses. Prime farmland makes up about 30 percent of the land being converted to nonfarm uses. If this same proportion applies to the entire 95 million acres of urban land and rural land used for transportation in the Nation

today, we have already lost 28.5 million acres of prime farmland--an area larger than the size of Ohio.

Less energy is needed to produce crops on prime farmland soils than is needed on other soils. If prime farmland is converted to nonfarm uses farmers often have to shift production to less suited soils where the energy requirements for a given level of production are greater.

If 100 extra pounds of nitrogen fertilizer were required on each acre of this less productive farmland, for example, about 100 million additional pounds of nitrogen would be needed each year. Since about 31,000 Btu's are required to produce 1 pound of nitrogen, about 3.1 trillion Btu's would be expended in the production of the nitrogen fertilizer. Because an additional 1 million acres would be lost each year, the total energy loss would be compounded over the years. Reducing by half the acreage of prime farmland converted to other uses could, therefore, save an estimated 78 trillion Btu's per year in fertilizer production alone by 2030.

Agricultural Water Management.--Energy can be conserved in agriculture by changing traditional water management practices, primarily irrigation and drainage.

o Irrigation.--About 14 percent of the cropland and about 4 percent of the pastureland in the country are irrigated. Because of the energy required to lift, transport, and distribute water, irrigation requires large amounts of energy. In 1977, irrigation consumed about 260 trillion Btu's of energy, or about 11 percent of the total energy used on farms. USDA (1977a) estimates that improved irrigation methods could save 53 trillion Btu's annually. Any reduction in the amount of water used or any improvement in the efficiency of irrigation systems translates directly into energy savings. Also, any reduction in use of fertilizer or other agricultural chemicals as a result of more efficient irrigation reduces energy use.

o Drainage.--Nationwide, nonfederal land includes 270 million acres of wet soils, about 105 million acres of which are now cropland. About half the acreage of cultivated wet soil is adequately drained and can be tilled efficiently. The 1977 National Resource Inventories (USDA, 1978b) indicate that 34.2 million acres of undrained cropland still need drainage. This figure includes land in row crops, close-growing field crops, rotational hay and pasture, summer fallow, orchards, vineyards, bush crops, improved hay, wild hayland, and other cropland not harvested or pastured. It does not include wetlands or other natural areas. In addition 16 million acres have been partly drained.

Draining this undrained and poorly drained cropland would save energy and increase production. More energy is needed to till inadequately drained land than adequately drained land. More energy is needed to pull tillage equipment on wet clayey soils, and some farming operations must be repeated in wet areas. On many wet soils soil compaction is a problem that also increases energy requirements.

The results of earlier studies (USDA, 1967; USDA, 1975) indicate that if the 34.2 million acres of cropland were drained, 137 million gallons of fuel per year, or about 16.4 trillion Btu's, could be saved. The improved drainage on

this 34.2 million acres could produce an increase in yields equal to the average yield from 12 million acres of cropland.

On the 16 million acres that have been partly drained, the full savings in fuel estimated above cannot be expected from full drainage development. It is reasonable, however, to expect fuel savings per acre to be about half those projected for undrained cropland. Thus, about 34 million gallons of fuel, or about 4 trillion Btu's, could be saved through improved drainage on partly drained lands. In addition, the increased yields from draining these lands would equal the average yield from 3 million acres of cropland. Assuming that 25 percent of the total costs of improving the drainage on 52 million acres of cropland and the irrigation management on 30 million acres of cropland is for energy conservation, the annual costs would be $850 million between now and 1990. These costs would include investments in research, field trials, information and education, grants and loans, and private investments.

Management of Pasture and Range.--Meat production requires high indirect use of fossil fuel, mainly in producing grains to feed livestock. Currently, feed grains make up more of livestock feed than they ever have before. Steers fed a formulated ration under confinement require about 400,000 Btu's of fossil fuel to gain 1 pound. The fossil fuel expenditure per pound of gain on range is very small. Studies conducted in 1974 show that cattle ranches in the Southwest used about 4 gallons of gasoline and 62 kilowatt-hours of electricity to produce 100 pounds of live beef. If these cattle did not graze on range but were fed harvested alfalfa hay, fossil fuel requirements would double and electricity needs would increase by 50 percent. Current demand for red meat, however, could not be met if all steers were produced on pasture and range alone.

Nitrogen fertilizer production is involved in the natural gas shortage because natural gas is the main fuel used in making this fertilizer. Although fertilizer use on pasture and range is small, studies show that the use of additional fertilizer on range and pasture is more economical and probably more energy efficient than the use of additional fertilizer on harvested grains and forage. Energy requirements are higher on well managed range and pastures than on poorly managed sites. Becase yields are greater, however, 58.1 million gallons of fuel, or 7 trillion Btu's, could be saved through good pasture management (USDA, 1975).

Shelterbelts and Windbreaks.--Windbreaks can significantly help to conserve energy in rural America, particularly in heating homes. Windbreaks can also help to save energy in snow removal, livestock feeding, and crop production.

Several studies have shown that windbreaks planted around farmsteads, ranch headquarters, and other rural residences can reduce energy consumption during the heating season by 10 to 30 percent. A study conducted by the Lake States Forest Experimental Station in Nebraska showed a savings of 23 percent (Bates, 1945). This study involved two identical houses, one protected by a windbreak and the other unprotected. A temperature of 70° F was maintained in each house.

A study in South Dakota reported similar results. A fully exposed, electrically heated house required about 65 percent more electricity to maintain

an inside temperature of 70° F from January 17 to February 17 than an identical house sheltered by a windbreak. The difference in average energy requirements for the whole winter was nearly 34 percent (Flemer, 1974).

A properly designed, 36-foot-high windbreak can reduce surface wind velocity by 35 percent or more for about 475 feet to the leeward. Table 3F-4 shows the percentage of fuel saved where windbreaks reduce surface wind velocity by 35 percent. The table shows that outside temperatures have much less effect on fuel savings than surface wind velocity.

Table 3F-4.--Percentage of fuel saved if wind velocity is reduced by 35 percent

Open wind velocity (mph)	Outside temperature in °F						
	-10	0	10	20	30	40	50
	(Percentage)						
5	13	12	12	12	11	11	11
7	17	16	16	15	15	15	15
10	23	22	21	20	20	19	19
13	27	26	26	25	24	24	23
15	30	30	29	28	27	27	26
18	34	33	32	31	31	30	30
20	36	35	34	34	33	33	32

Source: Bates. 1945.

The potential reduction in fuel consumption for home heating is significant, particularly in the Great Plains. The 1970 Census of Housing, conducted by the Bureau of the Census, shows that there were about 1 million dwellings in rural areas of North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma. USDA records show more than 480,000 acres of farmstead windbreaks in these same five states. An average farmstead windbreak is 2 acres. Therefore, windbreaks now reduce the energy needs for home heating in about 240,000 rural dwellings in these states.

In the Great Plains, an average sized house of 1,200 square feet uses from 800 to 1,200 gallons of fuel oil annually for heating. Assuming an average of 1,000 gallons of fuel oil and a 70 percent furnace efficiency, the energy heating requirement per home is 99 million Btu's per year. If a windbreak reduces fuel consumption by an average of 20 percent, each house with a windbreak saves nearly 20 million Btu's per year. If windbreaks could be

planted around the 760,000 unprotected rural dwellings in the Great Plains, the potential energy savings would be 15.2 trillion Btu's per year.

Substantial energy could be saved in home heating in many other areas as well. Using the estimates shown above, for every 10,000 windbreaks planted around rural residences, 200 billion Btu's could be saved per year. The 1970 Census of Housing showed that Montana, Wyoming, Colorado, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Indiana, and Ohio contained slightly more than 4 million rural dwellings. If windbreaks could be planted around only 20 percent of these dwellings not protected by windbreaks, 16 trillion more Btu's could be saved. The combined potential energy savings for the Great Plains and these other states is 31.2 trillion Btu's per year, or the equivalent of more than 221 million gallons of fuel oil annually.

Assuming that windbreaks could be established to protect 1.5 million rural residences by 1990, an investment of nearly $68 million annually would be required. This investment would include research, information and education, grants and loans, and private investments.

Areas Affecting Energy Generation and Substitution

Each of the following areas represents potential alternative ways to generate energy or to substitute new sources of energy for old. Because energy concerns are of relatively recent origin, some of the data and analysis in this section are preliminary and not as definitive as future reports will be. However, the data do suggest opportunities for and levels of magnitude of potential energy savings. The discussions of some of these areas present only the beneficial side of the opportunity. In considering any of these areas, it must be recognized that there will generally be an additional energy cost. The net energy gain must be carefully examined before deciding on a course of action.

Organic Wastes as Fertilizers.--About 800 million dry tons of organic residues are produced annually. These residues are often considered wastes, and they have, in fact, caused widespread pollution of water, air, and soils as various attempts to dispose of them properly have failed.

Because most organic residues originate in the soil, their production depletes the soil to some degree. However, most can be returned to the soil to improve it.

o Animal and poultry manure.--Livestock and poultry excrete about 175 million dry tons of manure annually. This manure is worth $4.67 billion as fertilizer. It contains 7.7 million tons of nitrogen (N), or 73 percent of the N purchased annually in commercial fertilizer; 1.9 million tons of phosphorus (P), or 79 percent of the P in commercial fertilizer; and 4.2 million tons of potassium (K), or 87 percent of the K in commercial fertilizer. Only 39 percent of the manure is produced in confined areas where it must be spread. The rest is dropped directly on pasture or rangeland, where it fertilizes the soil and increases forage production.

Of the manure produced under confined conditions, 73 percent is being spread over the land. Even though under the best conditions some N is lost before it reaches the soil, this manure still contains plant nutrients valued at

$1.02 billion annually. An additional $380 million could be saved on fertilizer each year if the remaining 27 percent were spread.

Of the 7.7 million tons of N in manures, 3 million tons are produced annually under confined conditions. At the current price of $300 per ton of N, the total value of this N is $900 million. About 63 percent of this N is lost before it can be applied to land as fertilizer. Thus, N valued at about $570 million is lost annually. About $160 million worth of N could be saved through improved management.

o Crop residues.--The Nation's cropland produces about 430 million dry tons of crop residues each year. About 68 percent of these residues are returned directly to the soil and about 26 percent are fed to livestock. Most of the residues fed to livestock are returned to the soil in manures (USDA, 1978a). In addition, 2.7 percent is sold for a variety of special uses, mostly in the chemical industry (USDA, 1978a). About 2.4 percent is wasted. These wasted residues are mostly from cotton (gin trash), rice, sugarcane, and grass seed. Assuming that the wasted residues have the same composition of N, P, and K as the total crop residue, their total fertilizer value would be about $75 million.

o Sewage sludges.--Sewage sludges amount to about 4.4 million dry tons annually, much less than livestock and poultry manures and crop residues (USDA, 1978a). If they were of high enough quality to be safely used as fertilizer, the plant nutrients in sewage sludges would be worth about $92 million annually. Currently, less than 25 percent of this amount, or $22 million worth, is returned to the land.

o Municipal refuse, logging residues, and industrial organic refuse.--Most of these organic wastes have value as fuel and can be used in energy generation. Some also have value for improving soils. About 70 percent of the 140 million tons of municipal refuse produced each year is biodegradable organic residues (mainly paper, food, and yard refuse). These wastes generally have limited value as fertilizer, but many could be used to improve soil tilth. Improving tilth would decrease the amount of energy needed in tillage.

Livestock and poultry manures worth $380 million, crop residues worth $75 million, and sewage sludges worth $30 million are not spread over the land. These wastes contain 1.4 billion pounds of N, 350 million pounds of P, and 1,450 million pounds of K. The energy required to produce this fertilizer is 51.2 billion Btu's. In addition, producing the amount of N lost annually through poor management of manures would require 33.2 Btu's. Therefore, if all the waste organic residues were spread and if manure-handling techniques were improved, 84.4 billion Btu's could be saved each year.

Biomass as an Energy Source.--USDA estimates that crop and wood residues on the Nation's nonfederal land could generate about 9,000 trillion Btu's of gross energy annually, or almost four times the energy used each year on the Nation's farms and ranches. This estimate assumes that only the residues that could safely be removed from the land without risking soil deterioration caused by soil erosion or compaction would be used.

o Crop residues.--On some of the Nation's cropland, crop residues could be removed for energy generation without risking erosion. Studies (Larson,

1979) show that 36 percent of the crop residues produced in the Midwest could safely be removed for energy generation. USDA estimates that more than 20 percent of the Nation's crop residues--about 91.1 million dry tons--could be so used.

Highly efficient technology for converting crop residues into usable energy has not yet been developed (Zeimetz, 1979). However, USDA can identify areas from which crop residues could be taken when the technology becomes available. The USDA estimate that 20 percent of the crop residues could be safely used is based on the assumption that conventional tillage is used. Burning crop residues to dry grain on farms and in grain elevators is a promising prospect for early study.

The crop residues produced each year total 430 million dry tons (USDA, 1978a). The average energy per dry ton of crop residues is 10.7 million Btu's; these crop residues therefore contain 975 trillion Btu's of energy, or about 40 percent of the 2,320 trillion Btu's of energy now used on farms and ranches.

o Producing biomass crops.--Table 3F-5 summarizes the potential production of biomass on land not now used as cropland and from crop residues on land now in crops. In developing table 3F-5, USDA used the following assumptions:

For land not now cultivated--

1. Class I land (see "land capability classes and subclasses" in the glossary) not now cultivated but having high or medium potential as cropland should not be used for biomass production. Such land would likely be converted to cropland. Forty percent of the residues from such cropland could be used for biomass. Annual production from this land would be 7 million tons. This total is not included in table 3F-5.
2. Yields of biomass, as either a primary or secondary crop, would vary by capability subclass, as shown in table 3F-5.
3. Land in subclasses VIs, VIc, VIIs, VIIc, VIIIs, and VIIIc has low potential for biomass production. The soils are too shallow, stony, salty, dry, or cold. Research, however, may identify plants that could provide biomass on such land.
4. Land in subclasses VIe and VIIe now in pasture and woodland could be shifted to biomass production but for this analysis was assumed to be needed for its present use. Such land in range should not be shifted because yields would be very low.
5. Land in subclasses VIw and VIIw is wetland. This land would be preserved, not used for biomass or other crops.
6. Irrigated pastureland in classes VI and VII will not be used for biomass production. This land is highly productive of forage crops used in producing red meat.

For land now grazed--

1. USDA estimates that good management could increase forage production by 50 percent on existing pastureland and rangeland (USDA, 1979d). Therefore, decreasing the acreage of pastureland and rangeland by one-third need not reduce total forage production if management levels could be appropriately increased.

Table 3F-5.--Potential biomass production

Land capability class and subclass	Biomass from land not now cultivated					Residue from land now cultivated			
	Land now in pasture	Land now in forest	Ethanol production	Plant residue yield	Potential production	Total cropland	Residue available for biomass	Yield	Potential production
	(Millions of acres)	(Millions of acres)	(Millions of gallons)	(Tons/acre)	(Millions of tons)	(Millions of acres)	(Percent)	(Tons/acre)	(Millions of tons)
I------------	0	0	----	----	0	31.3	40	1.5	18.7
IIe----------	18.8	12.7	8,190	7	2.4	89.2	5	1.0	4.6
IIw----------	9.5	8.3	4,628	7	10.6	58.4	40	1.0	23.3
IIs----------	2.5	2.0	-----		18.0	18.2	25	0.5	2.3
	30.8	23.0			31.0				30.2
IIIe---------	13.1	16.7	-----	6	178.6	79.3	0	----	0
IIIw---------	4.2	12.6	4,368	6	10.1	34.4	40	1.0	29.1
IIIs---------	2.0	5.1	-----	4	28.4	11.9	10	0.5	1.4
	19.3	34.4			217.1				30.5
IVe----------	0	15.3	-----	6	91.8	29.9	0	----	0
IVw----------	0	13.4	-----	6	80.4	6.6	25	1.0	10.6
IVs----------	0	7.9	-----	3	23.7	7.1	0	----	0
	0	36.6			195.9				10.6
V------------	0	0	-----	----	0		25	1.5	1.1
Subtotals--			17,186 1/		444.0				91.1
Total---									535.1 2/

1/ 1,461 trillion Btu's.
2/ 5,726 trillion Btu's.
7,187 trillion Btu's.

2. There are about 133.6 million acres of nonfederal pastureland. Therefore, almost 45 million acres now in pastureland could be used for biomass production without lowering total forage yields.
3. No rangeland or class IV through VIII pastureland should be used in producing biomass. This land is too fragile to be farmed intensively and is needed to help satisfy the Nation's projected demand for red meat. The 45 million acres of pastureland to be converted to biomass production, therefore, would come from land in subclasses IIe, IIw, IIs, IIIe, IIIw, and IIIs.
4. All the class II pastureland and half of the class III pastureland could be used for production of biomass and alcohol. Such land in subclasses IIe, IIw, and IIIw would be used to grow corn for alcohol. The rest would support close-growing crops for biomass.

For land now in commercial woodland--
1. Good management could increase production of wood crops by 33 percent on existing commercial woodland (USDA, 1979d). Therefore, decreasing the acreage of commercial woodland by one-fourth need not reduce production.
2. There are about 377 million acres of nonfederal forest land in the United States (USDA, 1978b). About 94 million acres, or 60 percent, of the commercial woodland in subclasses IIe, IIw, IIs, IIIe, IIIw, IIIs, IVe, IVw, and IVs could be freed for biomass production. Such land in subclasses IIe, IIw, and IIIw would be used to grow corn for alcohol. The rest would support close-growing crops used for biomass.
3. Woodland in classes V, VI, VII, and VIII is more fragile than the other commercial woodland and is needed to maintain production of wood crops. Land in subclass c could not economically produce biomass.

For land now cultivated--
1. Crop residues should not be removed for biomass production if they are needed to prevent erosion or maintain tilth.
2. Availability and yield of crop residues varies by capability subclass, as shown in table 3F-5.

For gasohol production--
1. The least erodible land now in pasture and forest would be used.
2. All available land in subclasses IIe, IIw, and IIIw would be used (See table 3F-5).

USDA would give high priority to developing or identifying plants best suited to production of biomass. The best suited plants will vary with the kind of soil and the climate. Plants used for biomass should be: (1) perennials or capable of reseeding themselves so that it is not necessary to till sloping soils every year, (2) highly productive of biomass, (3) easily harvested, (4) close growing in order to protect the soil from erosion and (5) should require minimum energy input.

o Gasohol.--Of the pastureland and forest land that could be used for energy production, it is most reasonable to use the more level land to pro-

duce grain for alcohol. Such land has fewer or less severe limitations than more sloping land and in general produces more grain.

Although grains other than corn can be used to produce alcohol, corn has a number of advantages. It can be readily converted to alcohol with existing technology, and it is at least as economically feasible as other grains (statement by Secretary Bergland before the subcommittee on Energy Development and Applications, Committee on Science and Technology, U.S. House of Representatives, May 4, 1979). Wheat and sorghum will return about the same number of gallons of ethanol per bushel (2.6), but production per acre is generally less. The Net energy gain must be considered on a per acre basis.

In table 3F-5, the average yield of corn is assumed to be 100 bushels per acre. It is assumed that conservation practices are used so that corn can be grown each year. It is assumed that all of the available acreage (land now used for pasture and woodland) in capability subclasses IIe, IIw, and IIIw would be used to produce corn for alcohol generation.

These lands could produce 6 to 7 tons (dry weight) of fiber crops per acre with a total energy content on combustion of about 70 million Btu's. As much as 75 percent of this energy can be captured for space heating by our most efficient furnaces. This is not a net gain, however, because the energy required to produce and harvest the crop is not included.

In contrast, the 100 bushels of corn per acre would produce 260 gallons of ethanol, or 22.1 million Btu's. Because ethanol is a processed liquid fuel, the yield of energy per acre in the form of ethanol is less than the yield measured by dry fiber weight. Again, this is not net energy production. Current technology does not permit energy-efficient production of alcohol from grains where petroleum products are used in the conversion process.

The corn crop would also produce 1 ton per acre of crop residue (dry) with a total energy value of 10.7 million Btu's. Where they can be removed from the soil with no risk of soil deterioration, these residues are available for biomass in the same proportion as on land in the same subclasses now cultivated.

For every gallon of ethanol, distillers dry grain feed worth $0.36 would be produced. The distillers dry grain from 100 bushels of corn would have a total value of $93.60 as feed (statement by Bergland, May 4, 1979). Large-scale ethanol production would likely force the prices of high-protein feed supplements down. The average composition of distillers dry grain compared with corn and soybean meal is shown in table 3F-6. The distillers dry grain has about half the ruminant digestible protein and twice the fiber content of soybean meal.

The total pastureland and woodland available for biomass production in subclasses IIe, IIw, and IIIw (table 3F-5) is 66.1 million acres. If used for corn, it could produce 17.2 billion gallons of ethanol having 1,461 trillion Btu's of energy. An analysis of various levels of production is presented in table 3F-7 (statement by Bergland, May 4, 1979). If 1.5 tons of residue were produced per acre and if 5 percent of the crop residues on lands in subclass IIe and 40 percent of the residues on lands in subclasses IIw and IIIw were used, a total of 247 trillion Btu's could be produced from the corn residue.

Table 3F-6.--Feeding values for corn, distillers dry grain, and soybean meal

Feed value	Corn	Distillers dry grain	Soybean meal
		(Percent)	
Dry matter----------------------	88.0	93.8	89.6
Crude protein-------------------	8.9	27.0	44.0
Crude fat-----------------------	3.5	9.0	0.5
Crude fiber---------------------	2.9	13.0	7.0
Ruminant digestible protein------	5.8	19.3	37.5

Source: Feedstuff. Vol. 47, No. 38. Sep. 19, 1975. pp. 33-38.

At $93.60 per acre, the distillers dry grain would have a total value of $6.1 billion, assuming a demand existed for such a large quantity.

At present, use of gasohol is encouraged by a provision of the 1978 National Energy Act, which exempts gasohol from the 4 cents per gallon federal gasoline tax. If this 4 cents were applied as a subsidy to ethanol production, the total subsidy would actually be 40 cents per gallon of ethanol because ethanol makes up only 10 percent of gasohol. The analyses of costs in table 3F-8, however, indicate that an additional subsidy of 17 cents per gallon would be required to cover the costs of ethanol production.

Small-scale ethanol generating units for onfarm use may prove feasible. Use of crop residues, grains, and other available organic residues in such units could produce significant amounts of fuel for use on the farm.

If all the corn produced in the United States were converted to ethanol, it could provide about 1,400 trillion Btu's, or less than 2 percent of our total energy requirement. If the exported corn, wheat, and sorghum were kept in this country and converted to ethanol, it would generate 600 trillion Btu's.

At a price of $20 per barrel of oil (one barrel of oil yields 5.8 million Btu's), $1 will buy 290,000 Btu's. At a price of $2.50 per bushel of corn, $1 will buy 88,400 Btu's. Therefore, the generation of alcohol from grain is not considered economical at this time. However, if alcohol ever becomes a practical substitute for gasoline, because of changes in prices, conversion technology, or use technology, greater demands will be placed on our more fragile lands. The risk of erosion and the need for erosion control will therefore be greater.

o Wood residues.--About 485 million dry tons of unused wood are produced annually in the United States (USDA, 1979d). (See table 3F-9.) About three-fourths of this wood is on forest lands. It includes excess growth, small noncommercial timber, logging residues, dead trees, and cull trees. On some land, the return of these residues to the soil is essential for maintaining soil productivity. On most soils, however, this is not the case.

Table 3F-7.--Agricultural implications of gasohol program options

	Gasohol program levels			
	5 billion gallons	10 billion gallons	15 billion gallons	20 1/ billion gallons
Ethanol required (billion gallons)-----	0.5	1.0	1.5	2.0
Corn feedstock required (million bushels) 2/-------------------------	190	380	570	760
Feedstock requirement (percentage of current corn reserve stock objective, 666 million bushels) 3/-------------	29	58	87	116
Feedstock requirement (percentage of current CCC feed grain inventory, April 5, 1979)----------------------	142	284	426	568
Corn acreage required (million acres) 4/---------------------------	1.9	3.8	5.8	7.7
Distillers dry grain production (million tons) 5/-------------------	1.6	3.2	4.8	6.5
Distillers dry grain production (percentage of 1976 domestic consumption of distillers dry grain)------------	428	856	1,283	1,711
Distillers dry grain production (percentage of 1976 production of high-protein feed supplement)--------	6.6	13.2	19.8	26.4

1/ A 20 billion gallon gasohol program would provide about 12 percent of the total annual gasoline needs of the transportation sector.

2/ Assumes 2.6 gallons of ethanol per bushel of corn.

3/ The current corn reserve stock objective is actually a range: 629-703 million bushels. The midpoint is used for convenience of calculation.

4/ Assumes corn yield of 100 bushels per acre.

5/ Assumes 16.8 pounds of distillers dry grain per bushel.

Source: Statement by Secretary Bergland before the subcommittee on Energy Development and Applications, Committee on Science and Technology, U.S. House of Representatives, May 4, 1979.

Table 3F-8.--Subsidy requirements per gallon for a 40 million gallon per year distillery

Feedstock costs ($2.50/bu corn)--------------	$0.96
Direct costs (fuel, labor, etc.)------------	.24
Indirect costs (administrative, marketing, plant overhead)---------------------------	.09
Capital recovery----------------------------	.32
Total---------------------------------	$ 1.61
Less octane credit-------------------------	-.15
Total---------------------------------	$ 1.46
Less distillers dry grain credit ($110/ ton) 1/-------------------------------	-.36
Total-------------------------------	$1.10
Less refinery gate price of nonleaded gasoline-------------------------------	-.53
Total---------------------------------	$ .57
Less federal gasoline tax exclusion--------	-.40
Estimated additional subsidy requirement per gallon of ethanol-------------------	.17

1/ Assumes 6.5 pounds of distillers dry grain per gallon of ethanol.
Source: Statement by Secretary Bergland before the subcommittee on Energy Development and Applications, Committee on Science and Technology, U.S. House of Representatives, May 4, 1979.

Table 3F-9.--Estimate of unused wood produced annually in the United States

Energy wood source	Amount	Energy equivalent
	(Millions of dry tons)	(Trillions of Btu's)
Forest:		
Excess growth and small noncommercial timber	230	3,565
Logging residues, dead trees, and cull trees	145	2,247
Other:		
Urban tree removal and wood wastes	70	1,085
Waste wood from land clearing	20	310
Forest products industrial waste	20	310
Total	485	7,517

(Source: USDA, 1979e).

Research is needed to find the most effective means of using this resource. Urban tree removal, scrap, and wasted wood from land clearing is largely unused. Most of it is placed in landfills or burned. The total unused amount of such wood is 90 million dry tons. The unused wood manufacturing wastes generated each year in the United States total 20 million dry tons (USDA, 1978a).

If appropriate technology could be developed, the total potential annual production of energy from wood residues on both federal and nonfederal land would be about 7,500 trillion Btu's. By the year 2030, the Society of American Foresters (1979) estimates that 15,000 trillion Btu's of energy could be produced annually from wood residues and that the Nation's demand for lumber and other wood products would still be met.

o Summary of potential production.--Our agricultural and forest lands could produce as much as 20,000 trillion Btu's per year. USDA assumes that 143.5 million acres now in pasture or woodland could be used for biomass production. If management is improved on all land used for pasture and woodland, this acreage will not be needed to meet current demand for red meat or wood crops, although more than 90 million acres have high or medium potential for cropland (USDA, 1977c).

In the future, the amount of land available for production of biomass as the primary crop will decline as more land is required to produce food and nonenergy fiber.

In order to meet the high level of demand for the year 2030, the acreage of cropland will be increased. The additional acreage would come largely from land now assumed to be available for producing biomass as the primary crop. Therefore, the acreage available for biomass production would decrease substantially over the next 50 years.

If appropriate technology becomes available to convert biomass to energy at a rate of 0.5 unit of net energy from 1.5 units of gross energy, the production would be substantial. About 2,100 trillion Btu's of energy could be produced each year from the yield on 49 million acres where biomass was the primary crop and from the crop residue that could safely be removed from 20 percent of the nation's cropland. Producing this energy would require an investment of $994 million annually between now and 1990. In addition, 480,000 onfarm converters and 20,000 community conversion plants may be required, at a cost of $1.7 billion annually during the same period. These estimates include investments in research and development, field trials, trial plants, information and education, loans and grants, contracts, and private investments.

Alternative Energy Sources on the Farm.--The U.S. Army Corps of Engineers has estimated that 26.6 million more kilowatts could be generated at existing small dams. Their report defined small dams as those less than 100 feet high, having a reservoir storage capacity of less than 10,000 acre-feet and a generating capacity of less than 5,000 kilowatts. This estimate assumes that all the storage capacity of these dams would be converted to storage for hydropower and used to produce electricity. Based on this assumption, the additional hydropower potential of these small dams would be about equal to that of existing large dams.

Small dams constructed under USDA programs offer little real potential for hydropower development because they are not built for that purpose. USDA estimates that a dam with 50 feet of hydraulic head could produce 100 kilowatts of power 25 percent of the time. To do this, however, 1-year's water requirement of 5,200 acre-feet would have to be allocated to energy production. Very few USDA-built dams have this kind of extra storage capacity. If the added storage were available, the cost to produce the 100 kilowatts of hydropower from a small dam would be over $1 million. Using conventional methods to produce 100 kilowatts during the same period of time would cost only about $100,000. As energy costs increase and shortages loom, however, USDA believes that studies should be intensified to identify sites where small dams could produce hydroelectric power. Within the next 50 years, it may be feasible to design many dams that USDA builds for water storage or flood control so they can also be used for hydropower.

Windmills are used to pump water for livestock, domestic use, and irrigation. Small windmills deliver from 2 to 20 gallons per minute, depending on the size of the mill and the elevation to which water has to be raised. Larger windmills that generate from 10 to 75 horsepower operate irrigation pumps. Windmills are also used in remote areas as a supplemental source of electricity, which is stored in batteries.

The data on the cost effectiveness of windmills as an energy source are inadequate. Some experimental wind energy conversion systems in areas with high average winds produce energy at a cost of approximately 6 cents per kilowatt-hour. Further development is expected to lower these costs.

The sun provides extremely large amounts of energy. This energy can be collected directly as heat or converted to electricity through photovoltaic cells. About 7 percent of the fossil energy used in agricultural production is used in low-temperature heat applications, which solar energy can efficiently supply. Such uses include crop drying, livestock shelter heating, poultry brooding, dairy water heating, and greenhouse heating. If the farm residence is considered part of agricultural production, solar energy can also provide space and domestic water heating.

Although energy from the sun is "free," equipment for its collection, storage, and use is not. For economical application of solar energy in agricultural production, equipment costs must be low and the energy collected must be usable for much of the year.

As better and cheaper equipment for farmstead energy systems is developed and as the price of conventional energy continues to increase, alternative energy sources--such as low-head hydro, wind, and the sun--will be important in reducing our dependence on imported fuels.

Legumes as a Source of Fertilizer.--A legume crop adds about 100 pounds of nitrogen (N) per acre to the soil annually. It also helps control soil erosion. Farmers have traditionally grown legumes mainly because of the value of the hay or forage. At a yield of 5 tons per acre and $30 per ton, this value is $150 per acre. The fertilizer value of the N is about $15 per acre. This value, although not recognized by all farmers, is an important inducement to grow legumes in the crop rotation. Also, production costs are about $57 less per acre for legumes than for corn.

About 31,000 Btu's of energy are required to manufacture a pound of N in fertilizer and transport it to the farm. If the legume produced 5 dry tons of crop residues per acre, its potential energy value would be 53.5 million Btu's per acre. In addition, 3.1 million Btu's per acre would not have to be expended in making fertilizer N. The legume crop, therefore, provides 56.6 million Btu's per acre. A corn crop would create about 75.5 million Btu's at a cost of about 6.2 million Btu's for N fertilizer.

Considering all energy used in growing the crop, a corn crop would produce 2.69 Btu's for every Btu invested, a tame hay crop 2.75 Btu's, and an alfalfa crop 4.24 Btu's (Pimentel, 1979). The N produced by a clover crop would provide more than half of the N required for the corn crop and about 12 percent of the total energy required. Because clover conserves both soil and energy, USDA should encourage its use.

In the last decade, legumes have been grown on 20 million fewer acres than in earlier years. Two billion pounds of nitrogen fertilizer were required to replace the N in the legumes that were not grown. Sixty-two trillion Btu's were required to make this fertilizer. This energy could have been saved if legumes had been grown.

For the purpose of this study, USDA assumed that the residues produced by the legume crop are needed to control erosion. These residues would contain 1,070 trillion Btu's of energy. Assuming 40 million acres of legumes are included in the cropping sequence on sloping lands, USDA estimates that an investment of $104 million annually would be required through 1990. This includes information and education, grants and loans, and private investment.

<u>Methane from Manures</u>.--About 175 million dry tons of manure are produced nationally each year. About 68 million tons are produced under confined conditions and must be collected and spread on land or used in other ways (USDA, 1978a).

Anaerobic digestion of 1 ton of manure will yield 10,000 to 16,000 cubic feet of synthetic natural gas (SNG), also referred to as bio-gas (NASNGP, 1975). About 60 percent of this SNG is methane gas. The rest is carbon dioxide, hydrogen sulfide, and other gases. Methane has an energy value of 1,000 Btu's per cubic foot. About one-third of the gas produced is used to heat the digesters and operate machinery (NASNGP, 1975). One ton of manure would, therefore, yield about 4,000 to 6,400 cubic feet of pipeline-quality methane gas, or about 4 to 6.4 million Btu's of energy. The manure would lose none of its value as fertilizer.

Although manure is not extensively used in energy production in the United States, it has considerable potential. USDA estimates that 25 percent of the manure produced under confined conditions could be used in methane gas production. The estimated net yield from this manure would be 68 billion cubic feet of methane gas, or 68 trillion Btu's. An estimated 600,000 methane conversion units, at a cost of $5,000 per unit, would be needed. An investment of about $360 million would be required per year between now and 1990. These costs are based on the assumption that 50 percent of the investment will be allocated to energy conservation objectives. These estimates

include investments in research and development, field trials, trial plants, grants and loans, information and education, contracts, and private investments.

Alternative Objective Levels

The U.S. Department of Agriculture plans to encourage farmers to use less energy per unit of production and, where feasible, to use agricultural products for generating energy. Following are alternative objective levels for energy conservation and generation

Objective Level 1.--High-level objectives would involve maximum USDA activity to promote energy conservation and the production of biomass for energy generation. An increase in the energy efficiency of agriculture (energy expended per unit of production) of more than 10 percent could be expected.

Objective Level 2.--Medium-level objectives would involve moderate USDA activity to promote energy conservation and the production of biomass for energy generation. An increase in the energy efficiency of agriculture of 2 to 10 percent could be expected.

Objective Level 3.--Low-level objectives would involve minimum USDA activity to promote energy conservation. Any significant change in the energy efficiency of agriculture would tend to reflect changes in the price of energy rather than the impact of government activity.

Recommendations for Future Analysis

A small interagency staff conducted the preceding analyses of opportunities to save or generate energy on farms and ranches in a limited period of time. Had more time and people been available, a more detailed and thorough evaluation would have been possible.

The following paragraphs identify areas for which more precise data are needed for future analyses. The Nation must develop efficient technologies that will reduce the dependence on fossil fuels in agriculture.

Conservation Tillage.--USDA needs a more detailed breakdown of the current and potential usage of reduced tillage. Alternative systems or methods of tillage that will achieve the most efficient use of energy should be identified by crop and kind of soil on which the crop is grown. USDA should also identify, for each of the crop-soil-tillage system alternatives, the required use of pesticides and other chemicals and their pollution hazards. USDA should also have accurate data for estimating comparative costs and energy needs so it can accurately calculate net savings.

Crop-Drying.--USDA needs data on the amount of fossil fuels used in drying specific crops. It should identify the form of energy used.

Fertilizer Use.--USDA needs better estimates on the extent of fertilizer overuse, by crop and by soil.

Agricultural Water Management.--USDA needs better estimates of the potential for minimizing energy use per unit of production through--

(1) converting to gravity irrigation
(2) converting to drip irrigation
(3) improving irrigation management
(4) limiting water use to best suited soils
(5) improving drainage of cropland.

Pasture and Range Management.--In order to more accurately estimate the potential to minimize energy use per unit of production, USDA needs data on the acreage under poor management. For example, for pastureland it would be helpful to know the acreage that is unfertilized and the acreage that needs stand improvement.

Shelterbelts.--USDA needs accurate data on the number of farmsteads in the central and northern states that are not protected by shelterbelts and the potential energy savings per farmstead, by state. It needs similar data for rural nonfarm residences where sufficient land is available to establish the shelterbelt.

Organic Wastes as Fertilizers.--USDA needs data on the number of farms in each county on which manures are misused and the total dry tons of manure that are misused. It also needs to know the total amount of sewage sludge available, the tonnage that is high in heavy metals and where it is located, and the kind, extent, and location of soils with a high tolerance for heavy metals. Total available tonnage (dry) of other forms of organic wastes also needs to be determined, by county.

Biomass as an Energy Source.--USDA needs to know the amount of crop residues that can be removed from the land for energy generation without causing long-term soil deterioration. It needs estimates by kind of soil for each crop in each major land resource area (MLRA) and county. USDA also needs to know the land available for production of biomass as a primary crop, by kind of soil, MLRA, and county. It needs to know the total acreage of noncropland that has the potential for biomass production, regardless of its current usage. The current usage of such noncropland needs to be determined.

Energy from Alternative Sources.--USDA needs data by state on the amount of energy that might be developed by selected target years, from hydroelectric, solar, and wind power on an individual farm or small watershed basis.

Legumes as a Source of Fertilizer.--USDA needs to know the acreage of cropland in each of several classes of slope, by kind of soil, MLRA, and state.

Methane from Manures.--USDA needs to know the number of farms that have the potential for producing methane from manures and the total amount of manure available, by county.

Farm Scale and Mechanization.--It is possible that smaller scale farm units which are more efficient in energy usage will eventually prove to be most profitable. USDA should continue to study this possibility so that options related to that possibility are not overlooked. There is no doubt, for example, that modern farm machines and chemicals use more calories of energy than people or horses would use to do the same amount of work. The cost of people and the horses needed to do the work, however, is prohibitive in other respects.

Producing today's crops using 1918 technology would require 61 million horses and mules. Producing this number of work animals from the current number would require 20 years. Once we had the animals, we would have to feed them; this would require 180 million acres of cropland, almost half the cropland now in cultivation. The diversion of all these acres to feeding work animals would drastically reduce the supply of food here and abroad and would greatly increase food costs to consumers. Moreover, performing the additional hand labor needed would require approximately one-third the total working population in the United States, almost eight times the number of persons now employed in agriculture. These statistics illustrate the fact that what is appropriate at one time is out of tune with other times when conditions are different. Agriculture is a dynamic system that adjusts continuously to the circumstances. Higher energy costs lie ahead and will prompt adjustments in agriculture.

References

Bates, Carlos G. 1945. Shelterbelt influences: II, the value of shelterbelts in house-heating. J. For. 43: 176-196.

Council for Agricultural Science and Technology. 1977. Energy use in agriculture. CAST Rep. No. 68, Agronomy Bldg., Iowa State University, Ames.

Engelstad, O.P., and W.D. Shrader. 1961. The effects of surface soil thickness on corn yields: II, as determined by an experiment using normal surface soil and artificially exposed subsoil. Soil Sci. Soc. Am. Proc. 25 (6): 497-499.

Flemer, William, III. 1974. Energy conservation with nature's growing gifts. Am. Assoc. Nurserymen, Washington, D.C.

Larson, W.E. 1979. Crop residues: Energy production or erosion control. In Spec. Publ. No 25, Soil Conserv. Soc. Am., Ankeny, Iowa.

Lyles, Leon. 1975. Possible effects of wind erosion on soil productivity. J. Soil and Water Conserv. 30: 279-283.

National Association of SNG Producers. 1975. Newsletter. Vol. 1, No. 45, August 15, 1975.

National Association of State Universities and Land Grant Colleges and the United States Department of Agriculture. 1978. Inventory of agricultural energy research and development and technology transfer. (unpublished)

Pendleton, D.T., and W.J. Lloyd. 1976. Fuel-fertilizer-food-forage-feed-fiber: The sense and nonsense of alternatives and substitutions. Soil Conserv. Soc. Am. Annu. Meet., Minneapolis, Minn., August 1976.

Pimentel, David. 1979. Energy in agriculture. In Food, climate, and man. Ch. 4.

Sampson, R.N. 1976. Energy analysis as a tool in conservation planning. Soil. Conserv. Soc. Am. Annu. Meet., Minneapolis, Minn., August 1976.

Society of American Foresters. 1979. Forest biomass as an energy source. Washington, D.C.

Soil Conservation Society of America. 1977. Conservation tillage: Problems and potentials. Spec. Publ. No. 20, Ankeny, Iowa.

Thomas, G.W. 1977. As energy shapes the future of agriculture. SW Energy-Minerals Conf., N. Mex. State Univ., Albuquerque. (unpublished)

United States Department of Agriculture, Soil Conservation Service. 1967. Conservation needs inventory.

United States Department of Agriculture, Soil Conservation Service. 1975. An assessment of the energy savings potential of soil and water conservation. (unpublished)

United States Department of Agriculture, Agricultural Research Service. 1977a. Potential for saving energy in irrigation. Washington, D.C.

United States Department of Agriculture. 1977b. A guide to energy savings for the field crops producer. Washington, D.C.

United States Department of Agriculture, Soil Conservation Service. 1977c. Potential cropland study. U.S. Dep. Agric. Stat. Bull. No. 578, 104 pp.

United States Department of Agriculture, Soil Conservation Service. 1978a. Improving soils with organic wastes.

United States Department of Agriculture, Soil Conservation Service. 1978b. 1977 National resource inventories.

United States Department of Agriculture. 1979a. Effects of energy conservation and production on soil and water conservation programs. RCA Policy Issue Group. (unpublished)

United States Department of Agriculture, Economics, Statistics, and Cooperatives Service. 1979b. Growing energy: land for biomass farms. Agric. Econ. Rep. No. 425.

United States Department of Agriculture, Economics, Statistics, and Cooperatives Service and Soil Conservation Service. 1979c. Soil depletion reference report. Southern Iowa River Basin.

United States Department of Agriculture, Forest Service. 1979d. RPA--An assessment of the forest and range land situation in the United States. (draft)

United States Department of Agriculture, Forest Service. 1979e. The outlook for timber in the United States. For. Res. Rep. No. 20, July 1979.

University of Nebraska, Department of Agronomy. 1979. A comparison of suggested fertilizer programs obtained from several soil test laboratory sources. Univ. Nebr. Agron. Dep. Rep. No. 29, Lincoln.

Van Doren, C.A., and L.J. Bartelli. 1956. A method of forecasting soil loss. Agric. Eng. 37 (1): 335-341.

Van Dyne, D.L., R.D. Reinsel, T.J. Lutton, and J.A. Barton. 1979. Energy use and energy policy. Structure issues of American agriculture. Agric. Econ. Rep. 438: 201-211.

Willis, W. O., and C. E. Evans. 1977. Our soil is valuable. J. Soil and Water Conserv. 32: 258-259.

Zeimetz, K.A. 1979. Growing energy: Land for biomass farm. U.S. Dep. Agric., Econ. Stat., Coop. Serv. Agric. Econ. Rep. No. 425.

Section G-Potential Problem Area 7, Related Natural Resources

Problem Statement

Three significant issues in the use of soil, water, and related natural resources are not addressed in the other potential problem areas. These issues--organic waste management, recreation, and soil and water resource management in urban and urbanizing areas--are addressed in this section.

First, modern agriculture produces great quantities of organic waste, often concentrated in such specific locations as feedlots and food processing plants. Urban areas produce such organic waste as sewage, septage, and refuse. Although some of this organic waste is returned to the land, much of it is dumped in waterways and oceans, and some is buried. Much of the waste that is presently discarded could be used to help improve soil tilth and fertility, and the cost of disposal would be less.

Second, modern society is demanding more opportunities for recreation. Although recreational activities are generally incompatible with intensive crop and livestock production enterprises, rural nonfederal land and water must continue to provide a large share of the outdoor recreational opportunities for a growing population. Satisfaction of these demands must be carefully integrated into our agricultural production system.

Finally, activities in urban and urbanizing areas can significantly damage soil, water, and related natural resources. For example, sediment from urban construction activities often severely degrades water quality in streams and decreases storage capacity in lakes and downstream impoundments. Urban growth often removes the most productive farmland from cultivation, thereby increasing the intensity of use of the remaining farmland.

In order to determine the significance of these problems, the U.S. Department of Agriculture reviewed a number of data sources. In analyzing the data, USDA compared probable future trends with attainable or desired conditions to determine where future soil and water conservation programs will be most needed.

Scope

USDA evaluated the scope of its opportunities for action in terms of soil and water resource management in urban and urbanizing areas, the use of organic wastes for improving soil tilth and fertility, and the impact of outdoor recreational demand on nonfederal lands in all parts of the country. These problems involve both public and private land. USDA decided to address these problems in a comprehensive manner because they can usually be handled by similar techniques or technology.

Focus

USDA will focus the programs directed at these problems on target areas; that is, it will concentrate either on geographic areas or on specific kinds of problems regardless of where they occur. The focus for some problems, such as erosion and sedimentation, may require both broad and targeted methods of controlling the problem. In the sense that it is broad, the USDA program

will provide general guidelines and methods to reduce erosion and sedimentation at construction sites. However, it will also designate critical sites that require specific treatment to serve as examples.

The focus for a program for controlling soil stability may also require both broad and targeted methods. In the sense that it is broad, the USDA program will address soil stability problems over the entire United States. Then, it will use records of broad mappings of soil properties, such as soil surveys, and records of specific soil stability mappings, such as landslide mappings, to identify specific areas having soil stability problems.

Results of the Analysis

Organic Waste Management.--Of the 175 million dry tons of animal manure produced annually in the United States, about 90 percent is currently returned to the land. However, the potential for better management is high. For example, the amount of nitrogen in manure now applied to the land could be nearly doubled--from 800,000 tons to 1.4 million tons per year.

About 23 percent of the Nation's sewage sludge and septage is spread on the land. The rest is held in storage lagoons, dumped in the ocean, burned, or placed in open dumps or landfills. However, open dumps and ocean dumping are being phased out, less land is available for storage lagoons, and more restrictions are being placed on incinerators and landfills.

The United States generates about 4.4 million tons (dry weight) of sewage from municipal waste treatment plants and septage annually. The amount of these wastes will probably increase by 25 percent within 10 years. Because of this, USDA expects more solid waste to be spread on the land. Although the potential for using sludge and septage to improve soil tilth and fertility is high, maximum use of these wastes will involve relatively small acreages of the Nation's total cropland. Proper concern for hazards to human health must be considered in using these wastes to improve soil tilth and fertility.

Most municipal refuse is taken to open dumps or sanitary landfills or is burned. Open dumps are being phased out as the use of sanitary landfills increases. Present trends indicate that by 1985 there will be nearly 198 million tons of municipal refuse to dispose of annually. Because smaller communities generally do not use incinerators, the selection of suitable landfill sites is a particular problem in rural areas. Municipal refuse has low potential for improving soil tilth and fertility (USDA, 1978c).

Other organic wastes that USDA knows can improve soil tilth and fertility are now being used almost to their maximum potential for this purpose. Of the nearly 70 million tons of wood manufacturing waste produced annually, more than 85 percent is used to make paper, chemicals, and other wood products. Most logging waste is scattered and left uncollected in the woods because the cost of collection is too high. Approximately 80 percent of food processing wastes are used for animal feed and are not directly available for improving soil tilth and fertility.

USDA will promote more efficient use of animal manure and increased use of sewage sludge and septage on the land. It will also give advice on the safe and efficient disposal of other organic wastes and municipal refuse through sanitary landfills and other acceptable methods wherever it is impractical to use these wastes in improving soil tilth and fertility.

Recreation.--Recreation is an important and growing land and water use. More people are demanding opportunities for outdoor recreation and will probably continue to do so. Meeting this demand will provide many benefits; at the same time, it will create a number of resource-related problems.

Because of the absence of a well defined market system, procedures to be used in predicting future demands for outdoor recreation are developed from a combination of data sources. Because cooperation between the public and private sectors is needed to meet future demands for recreational opportunities on private and other nonfederal lands, USDA will use data from the National Association of Conservation Districts and its own recreation needs projections to predict future private recreation needs. To meet recreational demands on private land, the Nation will also need to address the traditional resistance of many private landowners to public use of their land. Questions of liability, low returns, and possible property damage are often raised.

As a part of the Nationwide Outdoor Recreation Plan, the Heritage Conservation and Recreation Service (HCRS) conducted the National Outdoor Recreation Survey to determine the outdoor recreational activities in which people participate, the frequency of participation, and the factors that influence participation. Using the HCRS survey as a basis, USDA recently completed a series of long-range estimates of recreation participation extending to 2030. These projections use the expected number of participants as an indicator of the future demand for facilities. For the 1980 RCA reports, USDA will analyze these estimates and other existing data to determine future recreation needs, by type and region; determine whether existing resources and programs meet projected needs; identify recreation resources not now fully used; and determine what resources or methods can be used to increase or improve recreational opportunities.

USDA will closely coordinate its efforts for the 1985 RCA reports and develop appropriate data that it now lacks. In this way it will be able to better assess how, where, and to what extent its programs can meet the Nation's outdoor recreation needs and to analyze the effects of recreational activities on soil and water resources.

Soil and Water Resource Management in Urban and Urbanizing Areas.--Urban areas and rural transportation land occupy about 94 million acres in the United States. Nearly 3 million acres are converted to built-up uses annually, including about 1 million acres of prime farmland and 875,000 acres of either wet soils or soils susceptible to flooding.

Soil stability problems are significant in nearly every state. For example, a study by the California Division of Mines and Geology projects that between 1970 and 2000, losses from landslides in California will cause nearly $10 billion in property damage unless present soil management practices change (Alfors, Burnett, and Gay, 1973). Cracked foundations, disrupted utilities,

and damaged roads, bridges, and other structures all indicate soil stability problems.

Soil erosion and sediment damage in developing areas are serious problems. How sediment affects water quality is discussed in potential problem area 2, Water Quality. Urban areas contribute 4 percent of the nonpoint source sediment (see "nonpoint source pollution" in the glossary) in the Nation's waters. Phase II of the National Resource Inventories on soil erosion will show the extent of soil erosion in urbanizing areas. Although such information is not presently available for the entire country, onsite analyses indicate that erosion on construction sites is about 3 percent of the Nation's total erosion. Where it occurs, however, this type of erosion can be the most serious erosion problem in the area. The initial problem usually lasts for only several months to a few years, but it can disturb the environment for many years. Such damage is frequently offsite and may not directly affect the offender.

A 10-year study of soil erosion in Montgomery County, Maryland (an urban area), showed erosion rates of 16.1 to 226 tons per hectare, or about 30 tons per acre on construction sites annually. Another study (CEQ, 1978) reported erosion of 185.2 tons of soil per acre annually from some construction sites in Connecticut. Preliminary data from phase II of the 1977 National Resource Inventories (NRI) (USDA, 1978d) for Oklahoma indicate that construction sites cause 3 percent of that State's total erosion of 152 million tons annually. An SCS study of the gently sloping watershed of the Little Calumet River in the Chicago area indicated an average annual erosion rate of 24 tons per acre from construction sites. Projections of these figures indicate nationwide erosion of about 140 million tons of soil from construction sites annually. About 56 million tons reach streams or other water bodies. State and national data summarizing erosion from construction sites will be available in early 1980.

Wet soils and water management are problems in many urbanizing areas. For example, about 25 percent of new urban development around Columbus, Ohio, is on wet soils. Nationwide, about 28 million acres of urban areas are on wet soils. Related problems include wet basements, ineffective septic systems, poor conditions for lawns and gardens, and high maintenance costs for driveways and streets. Additionally, communities on wet soils frequently have mosquitos and other vectors. Wetlands converted to urban uses represent an estimated 175,000 acres yearly and are included in the estimated 875,000 acres of wet soils converted annually to urban uses.

There are 175 million acres of rural flood prone areas in the United States (USDA, 1978d). The Water Resources Council estimates that there are between 3½ and 5½ million acres of urban flood prone land (USWRC, 1978b). If the same proportion of flood prone areas occurs on urban and built-up areas as on rural lands, over 11½ million acres of urban land and rural transportation land would be in flood prone areas. An estimate by HUD places the figure at 24 million acres of flood prone land within the corporate limits of urban areas (HUD, 1979), but this estimate includes significant amounts of undeveloped land which would be classed as rural land in the 1977 NRI. Nationally, 21,000 communities of all sizes in both upstream and downstream

areas are subject to flooding that causes about $1.1 billion (1975 dollars) in damages annually. Of this amount, about $856 million occurs in downstream urban areas.

Sound soil and water management in urbanizing areas requires a better understanding of soil limitations and land use potential. Development should be avoided on soils with stability problems, flood prone areas, and wet soils. Where such soils are used, the limitations should be overcome before development. In addition, USDA policy encourages retention of prime farmlands for agricultural use.

Retention of prime farmland for agriculture is a national concern. It is estimated that of the 94 million acres of urban and urbanizing land, over 28 million acres were formerly prime farmland. Nearly 1 million acres of prime farmland are currently being converted to other uses annually.

Alternative Objective Levels

USDA examined three alternative objective levels for this potential problem area. Objective level 1 would be designed to solve most of the problems discussed in this section. USDA would attempt not only to define related resources problems but also to initiate new programs to solve them. Objective level 2 would be designed to solve many identified problems, but with limited new actions. It would, however, include substantial efforts to search out related resources problems and define them quantitatively. Objective level 3 would be designed to solve only extreme problems and to use existing USDA programs.

Objective Level 1.--Under objective level 1, USDA would seek to add 61 million dry tons of the 374 million tons of organic wastes presently not being used to improve soil tilth and fertility to the 456 million tons now being used on the land. It also would try to increase the present efficiency of use of nitrogen in animal wastes from 39 percent to 55 percent and to increase the value of organic wastes applied to the land by $60 million annually. This represents high efficiency with present management technology.

Maximum feasible use of animal wastes and crop residue to improve soil tilth and fertility (an estimated 75 percent of all organic residues considered) would increase nitrogen values by $208.8 million. The total value of manure used in improving soil fertility could be increased from $1.02 billion to $1.53 billion with improved management. Quantification of soil tilth values is difficult. Objective level 1, therefore, would seek to establish long range values of organic wastes for this purpose. See figure 3G-1.

Recreation lands are projected to increase by nearly 1 million acres annually. Objective level 1 would require all lands developed for recreation use to meet soil loss standards for water quality or soil loss tolerance values (see "Universal Soil Loss Equation," chapter 7, section A), whichever are less. Existing land used for recreational purposes would be adequately treated to meet soil loss tolerance values. Landowners would receive conservation planning assistance to ensure proper soil and water management on lands used for recreational purposes. See figure 3G-2.

Quantification of objectives for soil and water management in urban and urbanizing areas must include both the onsite and offsite effects of flooding, erosion, and wet soils. In 1975, in addition to urban damages cited in potential problem area 5, Upstream Flood Damages, urban flooding in downstream areas caused damages estimated at $856 million. Such damage is projected to reach $1,259 million annually by 2000. Total urban damages from flooding in 1975 exceeded $1.1 billion. Upstream urban damages are not directly addressed in this section because they are covered in potential problem area 5, Upstream Flood Damages. However, a program that addressed downstream flooding would also provide direct and indirect benefits in upstream areas. Under objective level 1, USDA would seek to contain flood damage in urban areas to 1975 levels.

Problems associated with wet soils would be addressed by overcoming limitations on all wet soils as they are converted to urban uses. USDA would try to minimize this conversion. Where wet soils are being converted, attempts should be made to overcome the limitations in an environmentally defensible manner. No wetlands would be converted to urban uses.

Erosion from urban areas is largely caused by construction. Construction site erosion, currently estimated at about 140 million tons annually, would be limited to amounts permissible to reach water quality objectives or soil loss tolerance values (see "Universal Soil Loss Equation," chapter 7, section A), whichever are less.

USDA would seek to preserve prime farmland for agricultural purposes. Nearly 1 million acres of prime farmland are being converted to urban uses annually. Although projections to the year 2000 indicate an average loss of 540,000 acres of prime farmland annually, USDA considers this an unacceptably high rate. Over 22 million acres of prime farmland would be converted over the next 50 years. Objective level 1 would limit conversion to 50 percent of this total, or 11 million acres, by retaining prime farmlands for agricultural purposes wherever other lands are available for the proposed use. This objective level would be based on limiting conversion of prime farmland consistent with the current USDA policy on land use. See figure 3G-3.

Objective level 2.--Objective level 2 would be met by applying to the soil 50 percent of those unused organic residues having potential for improving soil tilth and fertility. The efficiency of nitrogen recovery through more effective management would increase from 39 percent to 49 percent (65 percent of the goal specified for objective level 1).

Recreational lands at objective level 2 would be protected from erosion at 50 percent of the levels specified for objective level 1. New recreational lands converted from other uses would be treated at 75 percent of the levels specified for objective level 1. USDA will provide conservation planning assistance at 56 percent of demand projections.

Soil and water management at objective level 2 would seek to limit flood damages to 40 percent of projected increases and to overcome limiting conditions on wet soils on at least 50 percent of the soils converted to urban uses. Sediment delivery from construction sites, now estimated at 56 million tons annually, would be reduced to 28 million tons.

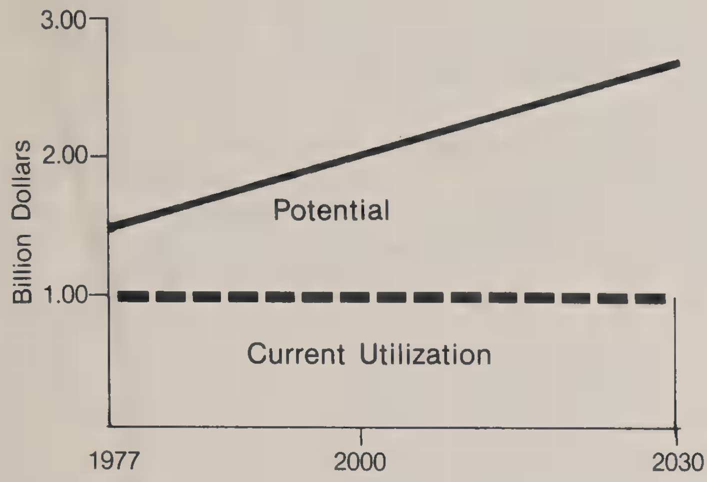


Figure 3G-1.--Organic waste nutrient value.

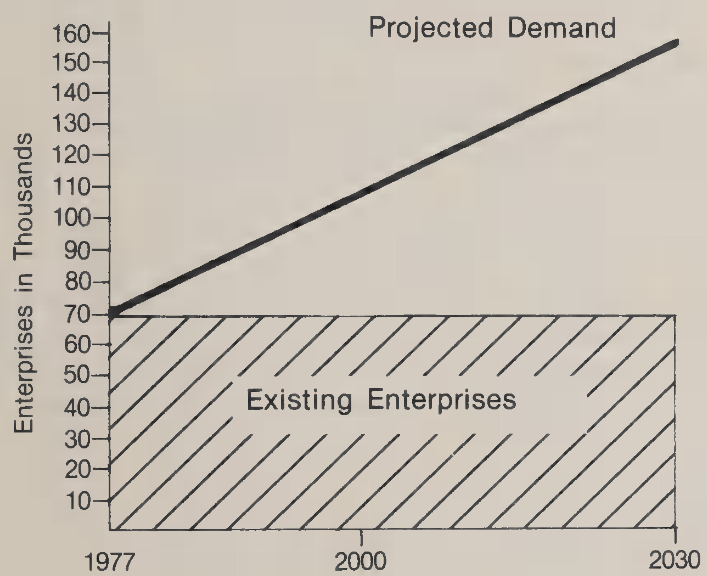


Figure 3G-2.--Recreation enterprises.

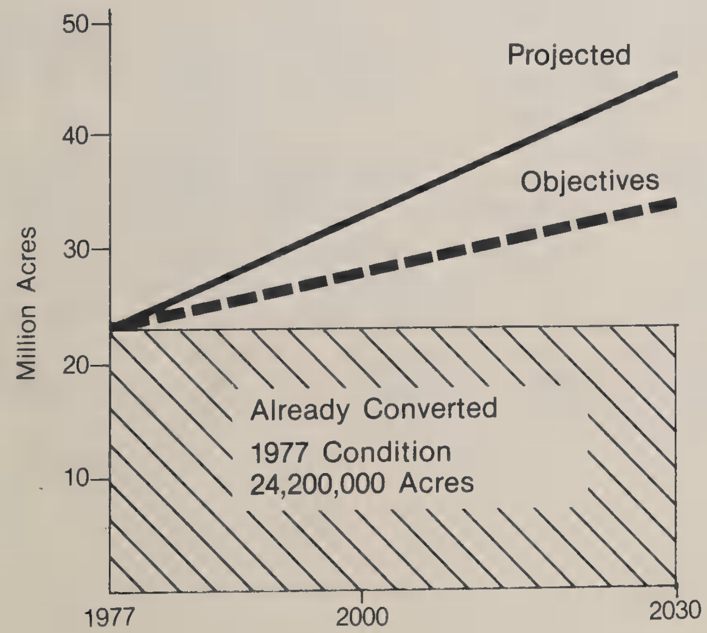


Figure 3G-3.--Prime farmland converted to urban land.

Objective level 2 would limit conversion of prime farmland at 50 percent of the level set for objective level 1. Conversion would be held to 16½ million acres over the next 50 years.

Objective level 3.--Organic waste management goals at objective level 3 would increase the amount of organic wastes used for tilth and fertility to 20 percent of the levels set for objective level 1. Nitrogen recovery efficiency values would increase to 47 percent (50 percent of the goal set for objective level 1).

Recreation lands under objective level 3 would be treated at 25 percent of the levels set for objective level 1. Recreation lands converted from other uses would be treated at 50 percent of the levels set for objective level 1. USDA would provide conservation planning for recreational developments at 37 percent of projected demand. Conversion of prime farmland would be held to 90 percent of unconstrained projections, or to 20 million acres.

Recommendations for Future Analysis

USDA should conduct additional research and data collection activities in several areas before it develops its 1985 soil and water conservation program. Among these areas are:

- The true value of organic waste in improving soil tilth and fertility. This value has not been adequately demonstrated. USDA should search existing literature and incorporate the results of current and future research into its analysis. In this way it can develop an adequate picture of the costs and potential effects of large scale use of organic wastes on soil.

- The magnitude and extent of erosion from urban construction sites. USDA should more comprehensively analyze these effects and develop the full costs and benefits of adequate precautionary treatment.

- The effects of recreational activities on resources. USDA should develop, test, and use better market-oriented recreation demand models to provide more meaningful estimates of the demands recreation will place on nonfederal soil, water, and related resources.

- The effects of conversion of prime farmland to nonagricultural uses. USDA should more thoroughly investigate and analyze these effects. Much of this work will probably be accomplished during the National Agricultural Lands Study, now underway.

References

Alfors, J. T., J. L. Burnett, and T. E. Gay, Jr. 1973. Urban geology--master plan for California. Calif. Div. of Mines and Geol. Bull. 198, 112 pp.

Boysen, Stephen M. 1977. Erosion control in urbanizing areas. Proc. Natl. Symp. Soil Erosion and Sedimentation by Water, Dec. 12-13, 1977.

Council on Environmental Quality. 1978. Ninth annual report.

National Association of Conservation Districts. 1977. Inventory of private recreation facilities--1977. League City, Tex., 155 pp.

United States Department of Agriculture, Forest Service. 1978a. An assessment of the forest and range land situation in the United States (review draft). 556 pp.

United States Department of Agriculture, Forest Service. 1978b. The private outdoor recreation estate. Southeast. For. Exp. Stn., 48 pp.

United States Department of Agriculture, Soil Conservation Service. 1978c. Improving soils with organic wastes.

United States Department of Agriculture, Soil Conservation Service. 1978d. 1977 National resource inventories.

United States Department of Housing and Urban Development. 1979. Evaluation of the economic, social, and environmental effects of floodplain regulation.

United States Department of the Interior, Bureau of Outdoor Recreation. 1973. Outdoor recreation, a legacy for America. 89 pp.

United States Department of the Interior, Fish and Wildlife Service. 1977. 1975 National survey of hunting, fishing, and wildlife-associated recreation. 91 pp.

United States Department of the Interior, Heritage Conservation and Recreation Service. 1978. 1978 Nationwide outdoor recreation plan (review draft). 513 pp.

United States Water Resources Council. 1978a. The Nation's water resources: 1975-2000. Second Natl. Water Assess. (draft).

United States Water Resources Council. 1978b. The Nation's water resources: 1975-2000. Second Natl. Water Assess. Flooding Technical Committee Report.

Meeting the goals of the Soil and Water Resources Conservation Act of 1977 will require the cooperation of landowners and land users (operators). The characteristics of owners and their leasing arrangements affect their awareness of the need for conservation and their ability to participate in conservation programs. Thus, knowledge about who owns the land and how it is operated is essential in developing resource conservation programs. Ownership factors that impede or promote soil conservation include the age, education, occupation, and financial resources of the owner, the type of proprietary arrangement, and the tenure arrangement for using the land (Held and Clawson, 1965). Also, the degree to which a conservation program is equitable is affected by the distribution of ownership of land in various uses (Boxley and Anderson, 1973).

Despite the need for ownership information in planning and implementing alternative conservation strategies, up to now few data have been available on the ownership of the 2.3 billion acres of land in the United States. The extent of public ownership of the land has been documented, but little has been known about the ownership of the remaining 58 percent (fig. 4-1). The Census of Agriculture focuses on operators (not owners) and only on farmland. Other surveys and inventories also have been specialized; they have focused, for example, on housing, taxation, or limited geographic areas.

To meet the need for information on landownership, the Economics, Statistics, and Cooperatives Service (ESCS) of the U.S. Department of Agriculture conducted a survey of private landowners in 1978 (USDA, 1979). The survey obtained information from 37,000 individuals, partnerships, and corporations representing about 28.8 million owners of 1.25 billion acres of privately held land in the United States. The 1.25 billion acre figure for all privately held land was 66 million acres less than an earlier ESCS estimate. This other estimate--roughly 1.3 billion acres--was arrived at by subtracting the acreage in federal, state, local governmental, and Indian holdings from the 2.3 billion acres of land in the United States (Frey, Summary for 1974). Data were obtained on ownership arrangements, acreage owned, land values, operating arrangements, and conservation investments for all privately owned land in the conterminous 48 states and Hawaii. Land in Alaska, Puerto Rico, and the Virgin Islands was not included in the survey. In this chapter only, land in Hawaii was included in the national totals but does not appear in any of the regional tables. In all other parts of the RCA reports, land in Hawaii was not considered a part of the Pacific Farm Production Region. Some variation occurs between certain statistics cited in this chapter and those appearing elsewhere in the Appraisal. This results from the use of different definitions and terminology by different government agencies.

ESCS also obtained data on such personal characteristics as the age, sex, and education of all private landowners. If the owner was not the sole proprietor (a single individual), the survey recorded the characteristics of the person who made the most decisions about the land. Corporations, unsettled estates, and institutions were excluded from this part of the survey.

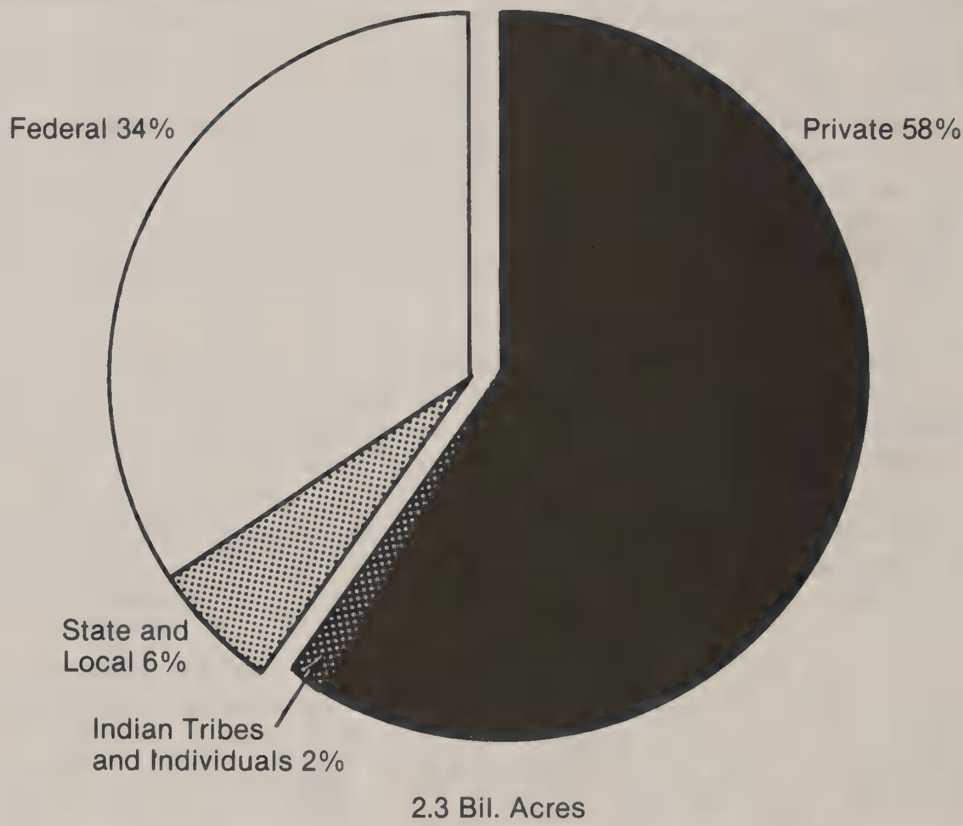


Figure 4-1.--Classes of land in the United States by ownership, 1974. (USDA. 1979. Agriculture Handbook No. 561)

Preliminary data from the landownership survey are useful in evaluating conservation strategies proposed under the Resources Conservation Act. Additional data from the landownership survey and complementary surveys on resource investment will be available for the annual reports to Congress and the 1985 RCA Appraisal and program development.

Ownership Data

A landowner (ownership unit) may be an individual, a group of individuals, or a legal entity such as a trust or corporation. More than 91 percent of the nonpublic owners of land in the United States own land primarily as sole proprietors or as married couples (fig. 4-2). These two groups own over 68 percent of all private land (table 4-1) and nearly 74 percent of the land on farms and ranches (table 4-2). Land on farms and ranches includes cropland, pastureland, rangeland, woodland, farmsteads, and other land.

There is considerable regional variation in the proportion of land owned by people in these two groups (table 4-1). For example, in the Pacific Region sole proprietors and couples own less than 50 percent of private land, whereas in the Corn Belt and Lake States Regions these two groups own more than 80 percent. More than 95 percent of the private landowners are sole proprietors and family groups, including couples, family partnerships, and family corporations. They own more than 89 percent of all private land and 92 percent of the land on farms and ranches. Nonfamily partnerships and nonfamily corporations, approximately 3 percent of the landowners, own about 12 percent of the private land. Again, regional variations are considerable. Only 2 percent of the private land in the Northern Plains Region is held by nonfamily groups, whereas 29 percent is held by nonfamily partnerships and corporations in the Pacific Region.

Ownership of private land is concentrated. In figure 4-3 the diagonal line represents completely equal distribution of private land among the Nation's landowners. For example, at the midpoint on the diagonal, 50 percent of the owners would hold 50 percent of the land. In fact, however, three-quarters of the landowners hold only 3 percent of the land. Less than one-half of 1 percent of the owners hold 40 percent of the private land. The large regional variation in the concentration of landownership shows some association with type of ownership. Ownership is less concentrated where more sole proprietors and couples and fewer nonfamily owners hold the land. Ownership of land on farms and ranches (table 4-3) is less concentrated nationally and regionally than ownership of all private land (fig. 4-3 and table 4-4).

Foreign citizens control only a fraction of 1 percent of the land in the United States. The U.S. Department of Commerce (1976) estimated how much land was owned by enterprises that are under 10 percent or greater foreign control. These enterprises owned only 4.9 million acres, or 0.4 percent of the Nation's private land (USDC, 1976; Wunderlich, 1976). The 1978 ESCS landownership survey estimates that foreigners who make the major decisions concerning the land own 1 million acres of noncorporate private land. No information on foreign interest in the 183 million acres of corporate land is available from the ESCS survey.

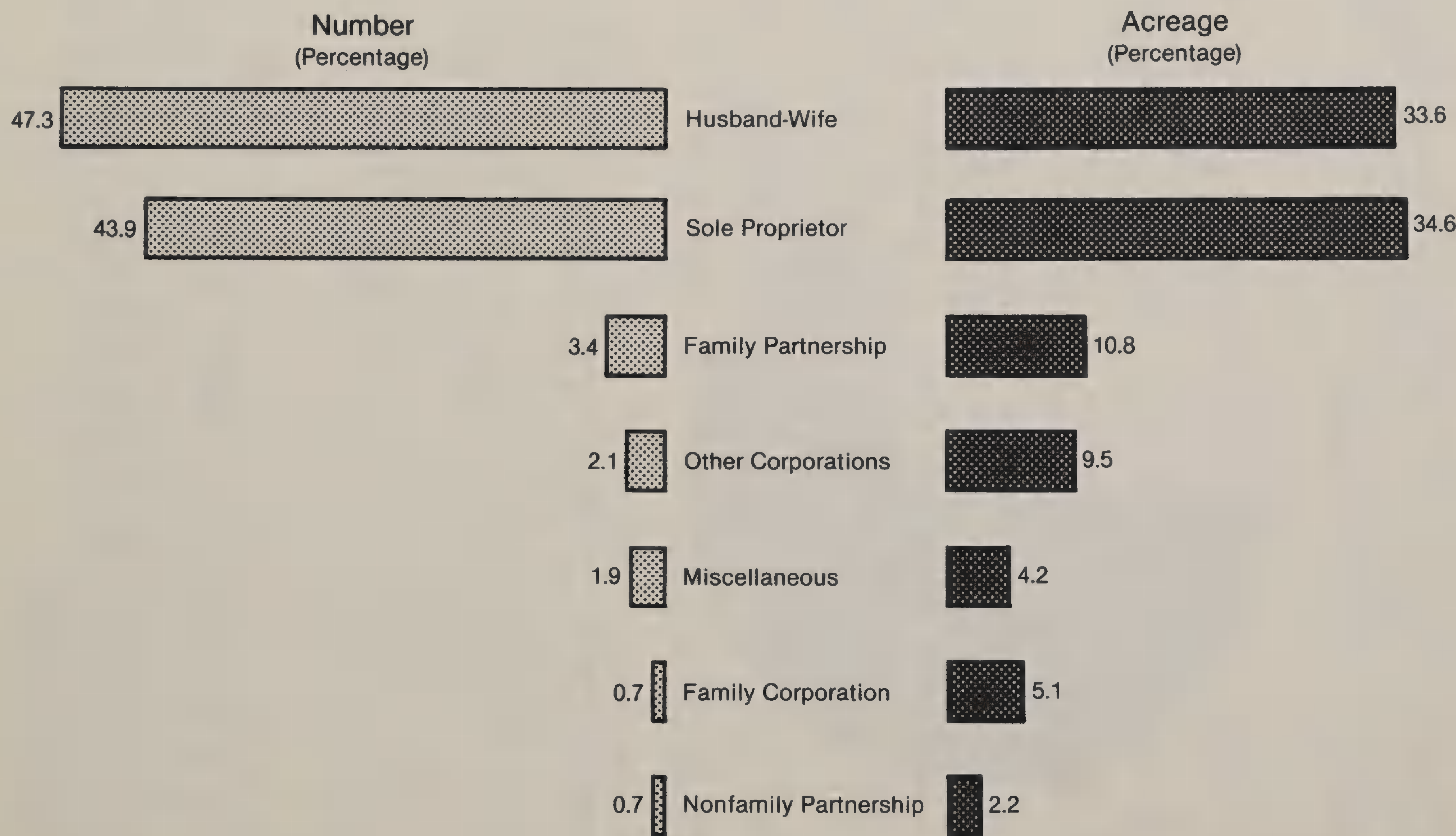


Figure 4-2.--Distribution of private land holdings in the United States by type of owner, 1978. (1978 ESCS landownership survey)

Table 4-1.--Regional distribution of ownership of all private land in the United States (excluding Alaska) by type of owner, 1978

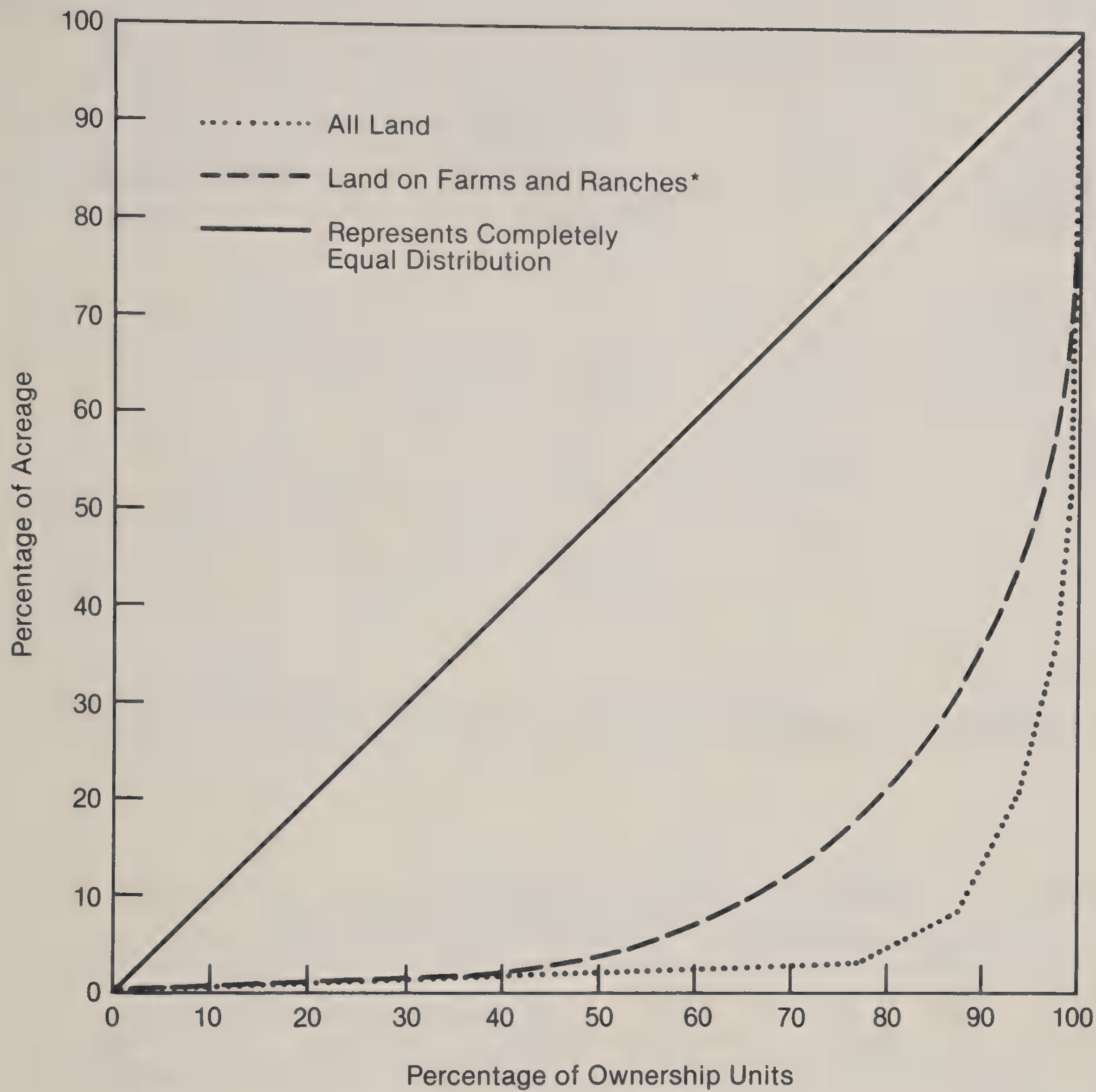
Farm production region	Sole proprietor	Husband-wife	Family partner-ship	Nonfamily partner-ship	Family corpora-tion	Nonfamily corpora-tion	Other	Total
	(Percentage of acres)							
Northeast----------	28.9	42.0	7.2	2.5	2.2	14.1	3.1	100.0
Lake States--------	34.7	47.6	6.9	1.3	1.6	6.6	1.3	100.0
Corn Belt----------	35.5	46.5	8.5	1.0	2.5	2.4	3.6	100.0
Northern Plains----	39.6	38.9	11.6	.9	4.7	1.3	3.0	100.0
Appalachian--------	36.8	35.6	9.5	2.1	2.0	10.2	3.8	100.0
Southeast----------	41.7	17.1	10.1	1.9	3.7	20.3	5.2	100.0
Delta States-------	39.8	23.0	10.7	2.0	4.9	15.4	4.2	100.0
Southern Plains----	40.4	29.1	14.3	1.9	2.8	4.2	7.3	100.0
Mountain-----------	26.5	28.7	12.9	3.5	13.9	10.9	3.6	100.0
Pacific------------	21.8	27.0	11.0	5.1	6.7	23.5	4.9	100.0
Total---------	34.6	33.6	10.8	2.2	5.1	9.5	4.2	100.0

Source: 1978 ESCS landownership survey.

Table 4-2.--Regional distribution of ownership of private land on farms and ranches in the United States (excluding Alaska) by type of owner, 1978

Farm production region	Sole proprietor	Husband-wife	Family partner-ship	Nonfamily partner-ship	Family corpora-tion	Nonfamily corpora-tion	Other	Total
	(Percentage of acres)							
Northeast----------	32.4	51.0	9.2	2.2	1.9	1.7	1.6	100.0
Lake States---------	36.7	51.4	7.1	.6	1.8	1.2	1.2	100.0
Corn Belt-----------	35.2	47.3	9.1	1.1	2.8	1.0	3.5	100.0
Northern Plains-----	39.5	38.8	11.6	.9	5.2	.9	3.1	100.0
Appalachian---------	40.9	40.0	11.7	1.9	1.8	.9	2.8	100.0
Southeast-----------	52.1	22.7	12.0	2.0	3.1	4.1	4.0	100.0
Delta States--------	44.5	30.1	13.4	1.5	4.7	2.2	3.6	100.0
Southern Plains-----	41.3	31.1	15.2	1.8	2.9	1.1	6.6	100.0
Mountain------------	26.8	31.8	13.9	2.9	16.7	5.6	2.3	100.0
Pacific-------------	25.8	35.0	15.1	4.9	10.4	5.2	3.6	100.0
Total------------	36.6	37.3	12.2	1.9	6.1	2.4	3.5	100.0

Source: 1978 ESCS landownership survey.



*Land on farms and ranches includes cropland, pastureland, woodland, wasteland, and farmsteads.

Figure 4-3.--Distribution of private landownership in the United States, excluding Alaska, 1978. (1978 ESCS landownership survey)

Table 4-3.--Regional concentration of ownership of land on farms and ranches in the United States (excluding Alaska), 1978

Farm production region	Percentage of land held by-- Top 5 percent of owners	Top 1 percent of owners
Northeast---------------	33	14
Lake States-------------	25	8
Corn Belt---------------	27	9
Northern Plains---------	32	15
Appalachian-------------	38	16
Southeast---------------	46	23
Delta States------------	45	21
Southern Plains---------	50	29
Mountain----------------	66	34
Pacific-----------------	70	41
Total---------------	51	29

Source: 1978 ESCS landownership survey.

Table 4-4.--Regional concentration of ownership of private land in the United States (excluding Alaska), 1978

Farm production region	Percentage of land held by -- Top 5 percent of owners	Top 1 percent of owners
Northeast---------------	73	42
Lake States-------------	53	23
Corn Belt---------------	52	21
Northern Plains---------	45	20
Appalachian-------------	64	34
Southeast---------------	79	53
Delta States------------	71	45
Southern Plains---------	70	45
Mountain----------------	91	65
Pacific-----------------	88	71
Total--------------	75	48

Source: 1978 ESCS landownership survey.

Although 52 percent of the adult population is female, women are the major decisionmakers for only 17 percent of the ownership units and control only 16 percent of the private noncorporate land (table 4-5). Although housewives make up 19 percent of the adult population in the United States, they are the major decisionmakers for only 4 percent of the private noncorporate land (table 4-6). Men are the major decisionmakers for 83 percent of the noncorporate ownership units and 84 percent of the noncorporate land. Male ownership is most preponderant in the Mountain and Lake States Regions (table 4-7).

Table 4-5.--Distribution of ownership of private noncorporate land in the United States (excluding Alaska) by sex, 1978

Sex	Adult population 1/	Ownership units (landowners) 2/	Acres owned 2/
		(Percentage)	
Female--------	52	17	16
Male----------	48	83	84

1/ Noninstitutional population 16 years and older (U.S. Department of Labor, 1979).
2/ 1978 ESCS landownership survey.

The racial categories used in the ESCS landownership survey are not totally comparable to the categories used in other data sources. In the ESCS study, Hispanics--both black and white--are classed as an exclusive group. In U.S. Department of Commerce and Department of Labor surveys, Hispanics are not classed as a mutually exclusive group from blacks and whites. However, general comparisons are possible. Whites--Hispanic and non-Hispanic--account for 88 percent of the adult population, but white non-Hispanics own 98 percent of all noncorporate private land. Nonwhites--blacks (Hispanic and non-Hispanic), native Americans, Asians, etc.--make up 12 percent of the population of the United States, but nonwhites (including all Hispanics) own less than 3 percent of the land in the United States. Most black non-Hispanic ownership is in the Delta States, Southeast, and Appalachian Regions (table 4-8). Most of the Hispanic ownership is in the West.

Farmers, farm managers, and farm laborers, who make up less than 2 percent of the adult population, own 47 percent of all noncorporate land (table 4-6) and 56 percent of the land on farms and ranches (table 4-9). Retired people own the next largest proportion of land--18 percent. Farmers, retired people and corporations own approximately 70 percent of both private land and land on farms and ranches in the United States. The proportion of land on farms and ranches that farmers own and of all land that farmers own is highest in the Mountain Region and lowest in the Northeast, Appalachian, Southeast, and Delta States Regions (tables 4-9 and 4-10). Tenure arrangement, the land market, and the age, education, and resources of the owner may affect the perception of conservation problems and the willingness and ability to re-

Table 4-6.--Ownership of private noncorporate land in the United States (excluding Alaska) by occupation, 1978

Employment class	Adult population 1/		Ownership units 2/		Acres owned 2/	
	Millions of people	Percent-age	Millions of people	Percent-age	Millions of people	Percent-age
Farmers and farm managers-------	1.5	1	2.2	8	489.6	47
Farm laborers and supervisors----	1.3	1	.1	(3/)	3.0	(3/)
Professional and technical------	14.2	9	2.6	10	60.1	6
Managers and administrators (nonfarm)------	10.1	6	2.1	8	56.7	5
Sales workers----	6.0	4	1.5	5	27.5	3
Clerical workers-	16.9	10	.9	3	13.0	1
Craftsmen--------	12.4	8	4.0	15	44.3	4
Operative, including transport------	14.4	9	2.0	7	30.0	3
Nonfarm laborers-	4.7	3	1.1	4	18.4	2
Service workers--	12.8	8	.4	1	6.3	1
Military---------	2.1	1	.2	1	1.3	(3/)
Housewives-------	30.0	19	1.1	4	37.4	4
Retired 4/-------	13.0	8	6.1	22	184.3	18
Others 5/--------	21.6	13	3.0	11	74.7	7
Total 6/----	161.1	100	27.3	100	1,046.6	100

1/ Noninstitutional population 16 years and older (U.S. Department of Labor, 1979).
2/ 1978 ESCS landownership survey.
3/ Less than 0.6 percent.
4/ Estimated.
5/ Includes unemployed and those not seeking employment for such reasons as school or health.
6/ May not total because figures are rounded.

Table 4-7.--Regional distribution of ownership of private noncorporate land in the United States (excluding Alaska) by sex, 1978

Farm production region	Male	Female
	(Percentage of acres)	
Northeast	87.4	12.6
Lake States	90.1	9.9
Corn Belt	82.9	17.1
Northern Plains	83.0	17.0
Appalachian	82.1	17.9
Southeast	80.3	19.7
Delta States	80.0	20.0
Southern Plains	80.8	19.2
Mountain	90.9	9.1
Pacific	86.1	13.9
Total	84.5	15.5

Source: 1978 ESCS landownership survey.

Table 4-8.--Regional distribution of ownership of private noncorporate land in the United States (excluding Alaska) by race, 1978

Farm production region	White, non-Hispanic	Black, non-Hispanic	Hispanic	American Indian 1/	Asian 2/	Other	Total
			(Percentage of acres)				
Northeast----------	99.3	0.4	0.2	0.1	----	----	100.0
Lake States--------	99.5	0.2	0.1	0.1	----	0.1	100.0
Corn Belt----------	99.7	0.1	----	0.1	----	0.1	100.0
Northern Plains----	99.5	----	----	0.5	----	----	100.0
Appalachian--------	97.2	2.5	0.2	0.1	----	----	100.0
Southeast----------	94.9	4.4	0.4	0.1	----	0.2	100.0
Delta States-------	94.4	5.4	----	0.2	----	----	100.0
Southern Plains----	96.5	0.8	1.6	1.0	0.1	----	100.0
Mountain-----------	96.5	----	2.3	0.9	0.1	0.2	100.0
Pacific------------	96.5	0.1	1.5	0.6	1.1	0.2	100.0
Total----------	97.6	1.0	0.7	0.5	0.1	0.1	100.0

1/ Including native Alaskans.
2/ Including Pacific Islanders.
Source: 1978 ESCS landownership survey.

Table 4-9.--Regional distribution of ownership of private noncorporate land on farms and ranches in the United States (excluding Alaska) by occupation, 1978

Farm production region	Farmers 1/	White collar	Blue collar 2/	Retired	Other	Total
	(Percentage of acres)					
Northeast	44.7	19.2	16.2	16.1	3.8	100.0
Lake States	59.3	9.9	12.7	15.5	2.6	100.0
Corn Belt	48.0	13.8	10.4	22.6	5.2	100.0
Northern Plains	64.9	9.2	3.2	17.4	5.3	100.0
Appalachian	37.0	19.1	16.0	22.9	5.0	100.0
Southeast	36.5	20.6	13.5	23.6	5.8	100.0
Delta States	41.1	17.5	12.9	23.8	4.7	100.0
Southern Plains	52.8	20.7	6.4	16.0	4.1	100.0
Mountain	77.5	8.2	3.6	7.5	3.2	100.0
Pacific	58.6	14.9	6.5	17.3	2.7	100.0
Total	56.4	14.1	8.2	17.0	4.3	100.0

1/ Including farm managers and farm laborers.
2/ Including private household and service workers.
Source: 1978 ESCS landownership survey.

Table 4-10.--Regional distribution of ownership of all private noncorporate land in the United States (excluding Alaska) by occupation, 1978

Farm production region	Farmers 1/	White collar	Blue collar 2/	Retired	Other	Total
	(Percentage of acres)					
Northeast	28.0	23.5	20.1	17.3	11.1	100.0
Lake States	46.7	12.7	14.8	16.8	9.0	100.0
Corn Belt	41.4	13.7	11.3	22.1	11.5	100.0
Northern Plains	59.8	8.4	3.4	18.2	10.2	100.0
Appalachian	30.3	18.8	16.7	23.1	11.1	100.0
Southeast	27.6	22.2	12.6	23.4	14.2	100.0
Delta States	32.3	17.0	11.3	25.4	14.0	100.0
Southern Plains	47.2	18.9	6.3	15.3	12.3	100.0
Mountain	70.6	8.9	4.3	7.9	8.3	100.0
Pacific	46.1	18.9	8.1	17.7	9.2	100.0
Total	47.1	15.0	9.5	17.6	10.8	100.0

1/ Including farm managers and farm laborers.
2/ Including private household and service workers.
Source: 1978 ESCS landownership survey.

spond with conservation measures. Such factors compound the problem created by the time lag between cash outlays for conservation work and realization of the returns.

Nonowner operation can be a major stumbling block to adoption of conservation measures. Tenancy requires the concurrence of at least two decisionmakers on the appropriateness of conservation measures and the equitable shares of costs and benefits of the measures. Tenancy shortens the planning horizon. Lands operated under a complex tenure system are vulnerable to the problems that tenancy presents for soil and water conservation. The user of the land is often not the owner. Almost 10 percent of landowners rent property to others (table 4-11). Almost a quarter of all privately owned land is rented out to others. A little over 400 million acres, close to two-fifths of all land on farms and ranches, is operated by someone other than the owner.

Held and Clawson (1965) have suggested that 15 years is the practical upper limit of a farmer's planning horizon. According to the ESCS landownership survey, there is almost a 50 percent chance that a piece of land will be sold during a 15-year period. Unfortunately, studies indicate that the real estate market will place relatively little value on the land's conservation status (Held and Clawson, 1965). More than 50 percent of the private land has changed ownership at least once since 1960 (fig. 4-4). Almost 30 percent was acquired by the present owners between 1970 and 1978. Preliminary data from a special ESCS survey of buyers and sellers of land show that 18 percent of landowners in the United States bought land during the period 1975-77. The results of this survey, including information on the uses of land before and after sale and the owner's characteristics, will be available shortly. Evidence of changing ownership patterns may indicate the need for changes in conservation strategies.

A disproportionate amount of land is held by older people. Individuals 65 years and older control 31 percent of the private noncorporate land (table 4-12). Those in the 55-64 age bracket own 26 percent of the private noncorporate land.

Less educated landowners may be less familiar with the benefits of technical innovations and, thus, more likely to resist changes in land management practices. The educational level of owners, however, is not related to the extent of land holdings. Land held by individuals with 8 years or less of schooling is equal to that held by those with at least 4 years of college (fig. 4-5). About 32 percent of the private noncorporate landowners are persons with less than a high school education, and they control roughly 32 percent of the land.

Another factor that may affect adoption of land and water conservation measures is limitation of property rights. Mineral, water, and airspace rights may be assigned separately. Land may be subject to easements--for example, for utility lines--or to restrictive covenants. In the future, development rights may become a common separate right. Nine percent of the owners who responded to the ESCS survey hold land whose control is complicated by separation of oil, gas, or other rights (table 4-13). Eleven percent hold land that has major easements, such as a waterway or major utility.

Table 4-11.--Tenure arrangements of private landowners in the United States (excluding Alaska), 1978

Tenure	Ownership units (landowners)	Acres owned
	(Percentage)	(Percentage)
Full-owner operator 1/	8	28
Full-owner operator landlord 2/	1	6
Part-owner operator 3/	3	21
Part-owner operator landlord 4/	(5/)	2
Tenant-owner 6/	3	1
Nonoperator 7/	78	17
Nonoperator landlord 8/	7	25
Total	100	100

1/ Owner who farms only the land that he owns and who rents no land to others.

2/ Owner who farms only the land that he owns and who also rents land to others.

3/ Owner who farms the land that he owns and some land that is rented from others, but who rents no land to others.

4/ Owner who farms the land that he owns and some land that he rents from others, but who also rents land to others.

5/ Less than 0.6 percent.

6/ Owner who farms only land rented from others.

7/ Owner who does not farm any land and who does not rent any land to others.

8/ Owner who does not farm any land, but who rents land to others.

Source: 1978 ESCS landownership survey.

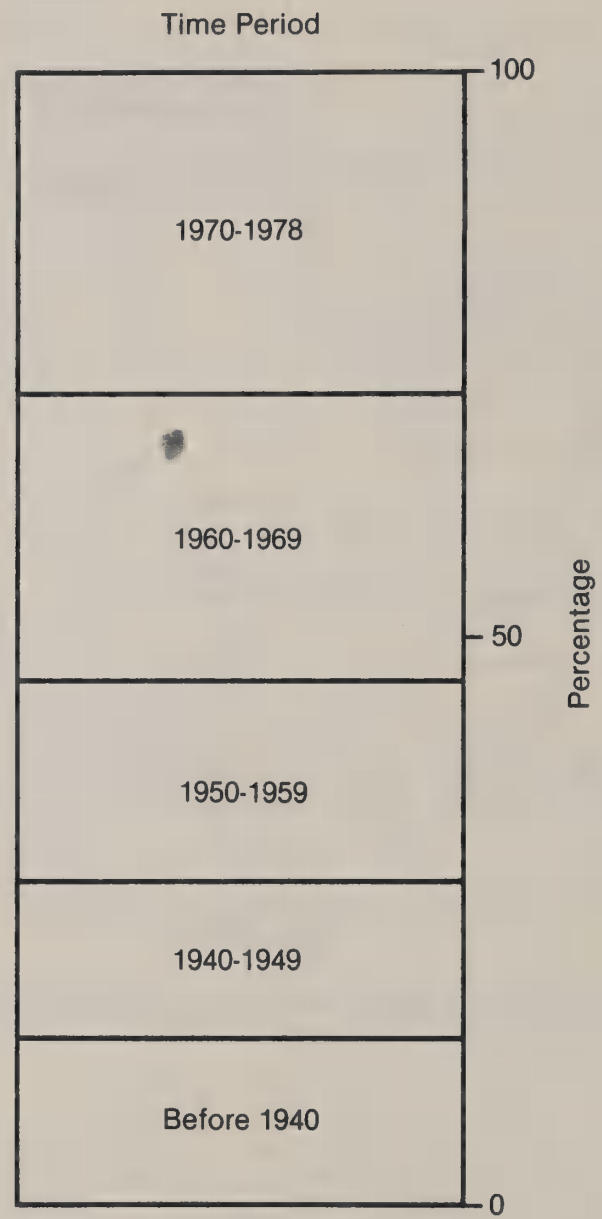


Figure 4-4.--Percentage of land acquisition in the United States, excluding Alaska, from before 1940 through 1978. (1978 ESCS landownership survey)

Table 4-12.--Distribution of population and ownership of private noncorporate land in the United States (excluding Alaska) for persons 16 years and older, 1978

Age	Adult population 1/		Ownership units (landowners) 2/		Acres owned 2/	
	Millions	Percentage	Millions	Percentage	Millions	Percentage
18-24-------	28.7	19	0.1	(3/)	4.3	(3/)
25-34-------	33.7	22	3.8	15	54.5	6
35-44-------	24.2	16	4.5	18	135.4	14
45-54-------	23.0	15	5.6	23	228.3	24
55-64-------	20.4	13	5.3	21	250.3	26
65 and over-	22.8	15	5.7	23	299.9	31
Total 4/-	152.7	100	25.0	100	972.7	100.0

1/ Noninstitutional population 16 years and older (U.S. Department of Labor, 1979).
2/ 1978 ESCS landownership survey.
3/ Less than 0.6 percent.
4/ May not total due to rounding of figures.

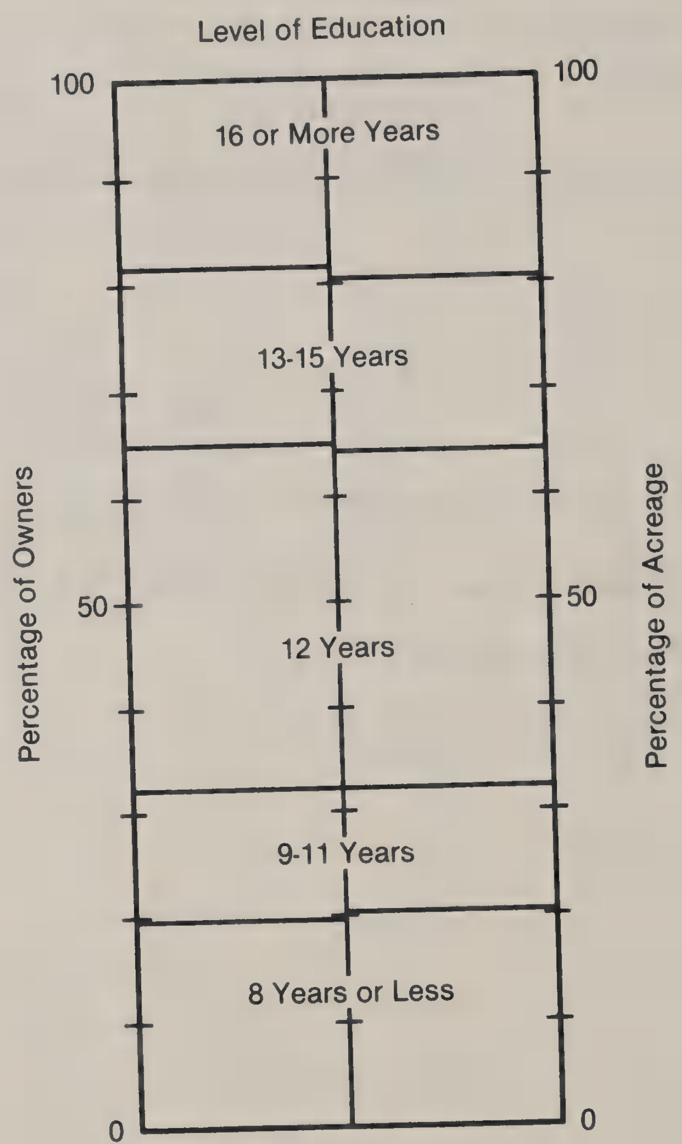


Figure 4-5.--Ownership of private noncorporate land by educational status in the United States, excluding Alaska, 1978. (1978 ESCS landownership survey)

Property taxes can have both a positive and negative influence on conservation investment. Three percent of United States landowners are in programs that permit a lower assessed valuation of land in agricultural or open space use (table 4-13). These special assessments result in lower taxes and may help reduce cash flow problems.

Table 4-13.--Possible limitations on adoption of conservation measures in the United States (excluding Alaska), 1978

Limitation	Ownership unit (landowner) response				
	Yes	No	Don't know	No response	Total
Special tax assessment for land in agricultural or open space use-------------------	788	23,867	2,433	1,734	28,822
Some property rights held by others 1/-------------------	2,397	22,804	2,185	1,436	28,822
Land subject to major easements-------------------	3,040	22,915	1,200	1,667	28,822

1/ Examples of such rights are water, mineral, and airspace rights.
Source: 1978 ESCS landownership survey.

References

Boxley, Robert F., and William D. Anderson. 1973. An evaluation of subsidy forms for soil and water conservation. In The Economics of federal subsidy programs--a compendium of papers submitted to the Subcommittee on Priorities and Economy in Government.

Frey, Thomas H. Major uses of land in the United States. Summary for 1974. (Unpublished manuscript).

Held, R. Burnell, and Marion Clawson. 1965. Soil conservation in perspective. The Johns Hopkins Press, Baltimore, Md. pp. 259-93.

United States Department of Agriculture, Economics, Statistics, and Cooperatives Service. 1979. Who owns the land? A preliminary report of a U.S. landownership survey. ESCS-70, 21 pp.

United States Department of Commerce. 1976. Foreign direct investment in the United States.

United States Department of Labor, Bureau of Labor Statistics. 1979. Employment and earnings. January 1979.

Wunderlich, Gene. 1976. Foreign investment in the United States real estate: Summary of the report. U.S. Dep. Agric.

Chapter 5 - Federal and Nonfederal Contributions to Soil and Water Conservation

Section A-USDA Soil and Water Conservation Programs and Funding

The Department of Agriculture administers many soil and water conservation programs. There are programs to inventory resources; inform the public about soil and water conservation; identify and locate conservation problems; research, plan, and design solutions; and establish institutional arrangements for action. USDA programs provide cost sharing, loans, and onsite technical assistance in conservation planning and implementation.

USDA agencies conservation administering conservation programs for nonfederal lands are the Soil Conservation Service (SCS); the Forest Service (FS); the Science and Education Administration (SEA); the Economics, Statistics, and Cooperatives Service (ESCS); the Agricultural Stabilization and Conservation Service (ASCS); and the Farmers Home Administration (FmHA). SEA funds two cooperative efforts at the state level--the Cooperative Extension Service (CES) and the State Agricultural Experiment Stations (AES). The Forest Service funds some of the activities of state foresters who provide assistance on nonfederal forest lands. Each agency develops and manages those programs assigned to it by Congress or the Secretary of Agriculture.

Three agencies administer conservation research programs. SEA conducts in-house research through its Agricultural Research branch and supports state AES research through its Cooperative Research branch. The Forest Service's research data on forest and range are available to land users through federal channels and state foresters and other state sources. Economic studies and models by ESCS also help in solving conservation problems.

SCS, FS, and ESCS conduct natural resource inventories, monitor the condition of resources, and analyze resource statistics. They provide such information as soil surveys and interpretations; data on land use, water supplies, and erosion; and information on range conditions. They also classify forest sites and develop and promote conservation plants for special sites. These agencies primarily collect data at the national, regional, and state levels for use in planning specific programs, but they also offer information on specific sites to aid local conservation work.

The Cooperative Extension Service (CES) publicizes research results and recommendations to help solve local problems in all phases of agriculture. CES directs less than 5 percent of its resources, however, toward soil and water conservation. Therefore, other agencies supplement CES efforts with their own information programs aimed at the clienteles for their programs.

USDA also relies on local organizations like soil conservation districts, extension associations, and county ASCS committees to create public awareness of conservation needs and outline courses of action. The landowner must seek assistance on the basis of information available from these sources.

USDA provides technical assistance for planning soil and water conservation to units of state and local government, private organizations, corporations, and individual land users. Planning grants to local entities are sometimes available from sources other than USDA. ESCS, FS, and SCS conduct Coopera-

tive River Basin Planning; and all USDA agencies assist state and local governments with Resource Conservation and Development (RC&D) activities. State foresters, with Forest Service assistance, provide woodland owners with help in onsite planning for forest management.

The technical assistance that SCS provides consists of resource inventories and surveys with interpretations, alternative solutions to soil and water conservation problems that will meet a land user's objectives, and detailed design and cost data for the solution selected by the land user. SCS provides technical assistance on soil and water conservation to FmHA and Federal Crop Insurance Corporation (FCIC) clients in accordance with memoranda of understanding with those agencies.

SCS, state foresters, and, in some areas, technicians on the payroll of state and local agencies provide technical assistance to help land users implement soil and water conservation plans. SCS also provides onsite technical assistance to land users to help them implement conservation plans under other programs. This onsite assistance includes designing practices, supervising construction, and certifying completion in accordance with standards and specifications.

USDA offers loans or cost sharing directly to land users and to units of government sponsoring soil and water conservation activities. The cost sharing is limited to out-of-pocket expenses. The cost-sharing rate varies. Cost sharing and grants are available for conservation practices under four programs administered by ASCS: the Agricultural Conservation Program, the Water Bank Program, the Forestry Incentives Program, and the Emergency Conservation Program. SCS administers six programs that provide cost sharing: the Watershed Protection Program, the Emergency Watershed Protection Program, the Flood Prevention Program, the RC&D Program, the Great Plains Conservation Program, and the Rural Abandoned Mine Program.

Individuals and associations may borrow money from FmHA to finance conservation activities. Generally, the borrower must have adequate security and be unable to secure financing from other sources. Units of government sponsoring watershed projects or RC&D measures may also borrow from FmHA.

For a more complete listing of USDA conservation programs and their legal authorities, see chapter 8, Federal Laws, RCA Appraisal, Part I. That chapter presents these programs and laws by subject area, for example, river basins, watershed protection, and forestry.

Federal Funding of Conservation Programs

Table 5A-1 shows the funding for USDA soil and water conservation programs for fiscal years 1977 and 1978. It gives obligated funds (those committed in that year for expenditure) and the number of staff-years devoted to each program.

The table also contains 2-year average figures. It should be noted that the information in this table has been provided directly by the USDA agencies and is limited to soil and water conservation programs. All or at least part of the federal outlays are listed in Budget Circular A-84. Table 5A-2 shows agency estimates of how their programs affect each of the seven potential problem areas (see chapter 3).

Table 5A-1.--USDA soil and water conservation programs and fundings

USDA soil and water conservation programs	Obligated funds 1/ in millions of dollars: Fiscal year 1977	Fiscal year 1978	Average	Staff-years: Fiscal year 1977	Fiscal year 1978	Average
ASCS Programs:						
Agricultural Conservation Program	169.5	184.7	177.1	2,540	1,836	2,188
Water Bank Program	16.3	13.2	14.7	23	20	22
Emergency Conservation Program	17.7	18.2	18.0	57	87	72
Drought-Flood Conservation Program	156.2	-4.3 2/	----	431	125 2/	----
Forestry Incentives Program	16.8	15.7	16.3	31	145	88
ESCS Programs:						
Resource Economic Research	1.5 3/	1.4 3/	1.5 3/	41	40	40
FmHA Programs:						
Farm Ownership 4/	68	83	76	54	66	60
Soil and Water	63	54	59	41	34	38
Emergency 4/	118	340	229	48	136	92
Irrigation and Drainage	6	1	3	4	(5/)	2
RC&D	1	1	1	(5/)	(5/)	(5/)
Watershed	5	12	8	3	7	5
FS Programs:						
Forest Watershed Management Research	8.0 3/	9.2 3/	8.6 3/	107	107	107
Cooperative Forest Management Technical Assistance	6.1	6.9	6.5	38	38	38
SEA Programs:						
Extension 6/	6.3	6.7	6.5	536	542	539
Agricultural Research	34.5	39.3	36.9	1,306	1,205	1,256
Cooperative Research	14.5	15.9	15.2	128	130	129

Table 5A-1.--USDA soil and water conservation programs and fundings--Continued

USDA soil and water conservation programs	Obligated funds 1/ in millions of dollars: Fiscal year 1977	Fiscal year 1978	Average	Staff-years: Fiscal year 1977	Fiscal year 1978	Average
SCS Programs 7/:						
Conservation Operations Program:						
Technical Assistance------------------	167.9	189.2	178.6	8,033	8,346	8,190
Inventorying and Monitoring-----------	5.6	6.0	5.8	246	231	239
Soil Survey---------------------------	41.2	40.7	40.9	1,657	1,572	1,615
Snow Survey and Water Forecasting------	2.3	2.4	2.4	61	62	62
Operation of Plant Materials Centers---	2.5	2.8	2.7	115	110	112
Resource Appraisal and Program Development----------------------------------	----	4.4	----	----	(5/)	----
Rural Clean Water---------------------------	----	.2	----	----	6	----
River Basin and River Basin Surveys and Investigations:						
SCS-----------------------------------	10.6	11.7	11.1	386	391	389
ESCS----------------------------------	2.6	2.5	2.6	90	68	79
FS------------------------------------	1.8	1.8	1.8	61	48	54
Total----------------------------	15.0	16.0	15.5	537	507	522
Watershed Planning:						
SCS-----------------------------------	10.5	12.0	11.3	382	397	389
FS------------------------------------	.7	.5	.6	36	15	26
Total----------------------------	11.2	12.5	11.9	418	412	415
Watershed Operations (PL-566):						
SCS-----------------------------------	130.4	116.4	123.4	1,858	1,759	1,809
ESCS----------------------------------	.1	.1	.1	1	1	1
FS------------------------------------	1.2	1.1	1.2	190	106	148

Table 5A-1.--USDA soil and water conservation programs and fundings--Continued

USDA soil and water conservation programs	Obligated funds 1/ in millions of dollars			Staff-years		
	Fiscal year 1977	Fiscal year 1978	Average	Fiscal year 1977	Fiscal year 1978	Average
FmHA	.4	.4	.4	64	47	55
Total	132.1	118.0	125.1	2,113	1,913	2,013
Flood Prevention (PL-534):						
SCS	22.1	19.1	20.6	477	483	480
ESCS	----	.1	.1	1	1	1
FS	4.1	4.3	4.2	48	28	38
FmHA	.2	.2	.2	2	2	2
Total	26.4	23.7	25.1	528	514	521
Emergency-Watershed-Operations:						
SCS	30.7	41.8	36.3	275	212	244
FS	2.5	2.4	2.4	64	57	60
Total emergency operations	33.2	44.2	38.7	339	269	304
Great Plains Conservation Program:						
SCS	22.0	22.0	22.0	331	336	334
ASCS	.1	.1	.1	2	2	2
Total	22.1	22.1	22.1	333	338	336
Resource Conservation and Development:						
SCS	29.0	30.8	29.9	702	678	690
ESCS	.2	.2	.2	5	5	5
SEA-ES	.2	----	.1	----	----	----

Table 5A-1.--USDA soil and water conservation programs and fundings--Continued

USDA soil and water conservation programs	Obligated funds 1/ in millions of dollars			Staff-years		
	Fiscal year 1977	Fiscal year 1978	Average	Fiscal year 1977	Fiscal year 1978	Average
FmHA	.2	.2	.2	11	11	11
FS	.8	.8	.8	4	2	3
Total	30.4	32.0	31.2	722	696	709
Rural Abandoned Mine Program	----	.4	----	----	10	----

1/ Obligated funds are committed for expenditure in a specific year.
2/ Reported in fiscal year 1977 and phased out during fiscal year 1978.
3/ Appropriated funds.
4/ Soil and water conservation funds and personnel only.
5/ Less than one staff year.
6/ Includes federal, state, and local funds (about 40 percent federal, 40 percent state, and 20 percent local).
7/ Administered by SCS. Other USDA agencies provide specific technical support for which SCS allocates funds from its appropriation.

Table 5A-2.--Estimated distribution of 1978 USDA conservation programs funding among potential problem areas

USDA soil and water conservation program	Total 1978 funds	Potential Problem Areas (PPA's): Soil resources, quantity and quality	Water quality	Water supply and conserva-tion	Fish and wildlife	Upstream flood damages	Energy conservation and production	Related resources
	(Millions of dollars)							
ASCS Programs:								
Agricultural Conservation Program	184.7	63.7	81.5	37.6	0.9		1.0	
Water Bank Program	13.2		0.2		13.0			
Emergency Conservation Program	18.2	16.1		2.1				
Forestry Incentives Program	15.7	6.4	9.1		0.2			
ESCS Programs:								
Resource Economics Research	1.4	0.7	0.4	0.2			0.1	
FmHA Programs:								
Irrigation and Drainage	1			1				
Resource Conservation and Development	1			1				
Watershed Loans	12			5	2	5		
Soil and Water Loans	54	5	4	39	5		1	
Emergency	340	199	28	88	10	10	5	
Farm Ownership	83	35	8	28	5	5	2	
FS Programs:								
Forest Watershed Management Research	9.2	1.3	3.8	2.3	0.3	0.1	0.5	0.9
Cooperative Forest Management Technical Assistance	6.9	5.0	0.2	0.2	0.6	0.2	0.2	0.5
SEA Programs:								
Extension	6.7	2.9	1.8	0.5	0.5	0.3	0.3	0.4
Agricultural Research	39.3	11.2	10.2	16.2		0.4	1.3	
Cooperative Research	15.9	3.3	2.3	0.3	2.3	3.4	1.4	2.9

Table 5A-2.--Estimated distribution of 1978 USDA conservation programs funding among potential problem areas--Continued

USDA soil and water conservation program	Total 1978 funds	Potential Problem Areas (PPA's): Soil resources, quantity and quality	Water quality	Water supply and conserva-tion	Fish and wildlife	Upstream flood damages	Energy Conservation and production	Related resource
	(Millions of dollars)							
SCS Programs:								
Conservation Operations:								
Technical assistance	189.2	94.6	28.4	28.4	9.5	9.5	9.5	9.3
Inventorying and Monitoring	6.0	3.6	0.6	0.3	0.3	0.9		0.3
Snow Survey	40.7	36.7	0.8	1.2	0.4	0.4	0.4	0.8
Snow Survey, Water Forecasting	2.4		0.3	1.2	0.3	0.3	0.3	
Operation of Plant Materials Centers	2.8	1.0	0.9		0.7		0.1	0.1
Resource Appraisal & Program Dev.	4.4	1.8	0.9	0.4	0.2	0.7	0.2	0.2
Rural Clean Water	0.2							0.2
River Basins Surveys and Investigations	16.0	3.3	4.1	3.1	1.6	2.4	0.8	0.7
Watershed Planning	12.5	0.2	0.2	0.8	0.6	7.1		3.6
Watershed Operations	118.0	2.0	2.0	7.7	5.9	66.7		33.7
Flood Prevention	23.7	0.4	0.4	1.5	1.2	13.4		6.8
Emergency Watershed Operations	44.2		0.9	0.4	2.2	0.4		40.3
Great Plains Conservation Program	22.1	13.2	1.9	4.4	1.1	0.2	1.1	.2
Resource Conservation and Development	32.0	11.9	3.0	6.2	2.0	6.1	0.6	2.2
Rural Abandoned Mine Program	0.4							0.4 1/
Total	1316.8	518.3	193.9	277.0	65.8	132.5	25.8	103.5
Percent of Total	100	39	15	21	5	10	2	8

1/ "Start up" costs for new programs, which will benefit PPA's 1-5 when operational.

Section B-Nonfederal Contributions to Conservation Programs

This section discusses nonfederal sources of money and manpower for soil, water, and related conservation programs, particularly those concerned with environmental demands and production of food and fiber. Data on state and local contributions to such programs are scarce. In fact, much of the information in this section is based on estimates by state and local sources.

Conservation Districts

Conservation districts are legal subdivisions of state government. They are mandated by law to develop and carry out soil and water conservation programs. Benefits of federal soil conservation programs are delivered primarily through conservation districts.

State soil conservation agencies (committees, boards, or commissions) are state government agencies that advise and supervise conservation districts. These agencies also serve as the principal official contact between conservation districts and the state legislature and governor's office.

Table 5B-1 shows the numbers of conservation district employees paid with state and local funds, by state, as of January 1979.

State and Local Funding for Conservation Programs

State and local governments are showing increasing interest in conserving soil and water. They have voluntarily increased funding to accelerate existing conservation programs that are primarily federally funded.

The number of federal employees involved in soil and water conservation programs has declined over the past decade. However, the number of employees paid with state and local funds has increased to more than offset this decline. This increase indicates that state and local governments see the need for applied conservation.

The Soil Conservation Service (SCS) reports annually on nonfederal funds and services contributed to conservation programs and on funds appropriated by state and local governments for conservation programs and soil surveys. Such contributions, which have increased steadily over the years, significantly increase the amount of conservation work done. SCS district conservationists prepare these reports from other available reports, records and agreements, and routine contacts with representatives of governments and organizations. They collect the information informally and, if necessary, use estimates. The state office supplements the district report and forwards the complete report to the national office.

Tables 5B-2 and 5B-3 show the nonfederal contributions of funds and services to soil and water conservation district programs in each state in fiscal years 1968 and 1978, respectively. Note that during the 10-year period, state and local contributions more than doubled, from \$95 million to \$212 million. Funds and services provided to Resource Conservation and Development (RC&D) projects in 1968 are included in the "all other" column in table 5B-2. "Conservation practice design and layout" and "conservation practice application" are shown separately for fiscal year 1978 (table 5B-3);

Table 5B-1.--Inventory of conservation district employees hired with state and local funds as of January 1979

State	Managers, executive secretaries			Secretaries, clerk/typists			Technicians			Equipment managers, operators		
	Total number	Full time	Part time	Total number	Full time	Part time	Total number	Full time	Part time	Total number	Full time	Part time
Alabama--------	0	0	0	51	20	31	4	3	1	0	0	0
Alaska---------	0	0	0	0	0	0	0	0	0	0	0	0
Arizona--------	0	0	0	31	0	31	0	0	0	2	0	2
Arkansas-------	0	0	0	76	0	76	3	0	3	1	0	1
California-----	15	3	12	28	3	25	5	1	4	9	3	6
Colorado-------	6	3	3	32	13	19	0	0	0	14	6	8
Connecticut----	3	3	0	8	3	5	3	3	0	2	2	0
Delaware-------	2	2	0	3	1	2	5	4	1	22	22	0
Florida--------	0	0	0	24	10	14	12	12	0	0	0	0
Georgia--------	0	0	0	0	0	0	0	0	0	0	0	0
Hawaii---------	0	0	0	3	0	3	1	1	0	0	0	0
Idaho----------	0	0	0	48	0	48	13	0	13	0	0	0
Illinois-------	39	39	0	98	60	38	10	10	0	0	0	0
Indiana--------	2	2	0	84	33	51	10	8	2	2	1	1
Iowa-----------	0	0	0	101	100	1	60	35	25	0	0	0
Kansas---------	1	0	1	138	20	118	56	1	55	11	0	11
Kentucky-------	3	3	0	121	25	96	30	0	30	0	0	0
Louisiana------	5	3	2	48	25	23	54	6	48	13	10	3
Maine----------	8	5	3	8	1	7	0	0	0	1	0	1
Maryland-------	16	15	1	28	21	7	28	28	0	0	0	0
Massachusetts--	1	0	1	14	0	14	0	0	0	0	0	0
Michigan-------	15	15	0	89	64	25	0	0	0	0	0	0
Minnesota------	8	8	0	92	29	63	90	50	40	42	0	42
Mississippi----	2	2	0	54	15	39	7	3	4	0	0	0
Missouri-------	0	0	0	110	23	87	0	0	0	0	0	0
Montana--------	4	1	3	49	13	36	21	8	13	1	0	1
Nebraska-------	24	24	0	126	91	35	55	40	15	25	25	0

Table 5B-1.--Inventory of conservation district employees hired with state and local funds as of January 1979--Continued

State	Managers, executive secretaries			Secretaries, clerk/typists			Technicians			Equipment managers, operators		
	Total number	Full time	Part time	Total number	Full time	Part time	Total number	Full time	Part time	Total number	Full time	Part time
Nevada---------	1	0	1	4	0	4	0	0	0	14	1	13
New Hampshire--	5	3	2	6	1	5	1	0	1	0	0	0
New Jersey-----	14	14	0	20	16	4	21	21	0	0	0	0
New Mexico-----	0	0	0	0	0	0	0	0	0	0	0	0
New York-------	35	35	0	40	30	10	43	27	16	10	5	5
North Carolina-	5	3	2	93	44	49	38	32	6	1	0	1
North Dakota---	0	0	0	62	8	54	10	0	10	137	2	135
Ohio-----------	20	20	0	99	88	11	141	120	21	2	2	0
Oklahoma-------	31	30	1	93	2	91	0	0	0	98	68	30
Oregon---------	6	4	2	11	3	8	3	3	0	0	0	0
Pennsylvania---	55	32	23	61	34	27	13	9	4	0	0	0
Rhode Island---	2	0	2	0	0	0	0	0	0	0	0	0
South Carolina-	3	2	1	46	0	46	0	0	0	0	0	0
South Dakota---	8	8	0	65	65	0	13	13	0	0	0	0
Tennessee------	4	4	0	64	40	24	29	5	24	0	0	0
Texas----------	40	1	39	99	2	97	9	0	9	11	3	8
Utah-----------	0	0	0	5	0	5	5	0	5	6	3	3
Vermont--------	1	1	0	7	0	7	0	0	0	2	1	1
Virginia-------	2	2	0	26	7	19	37	1	36	0	0	0
Washington-----	5	5	0	17	2	15	9	5	4	5	1	4
West Virginia--	3	3	0	19	13	6	0	0	0	11	4	7
Wisconsin------	34	34	0	61	32	29	30	25	5	0	0	0
Wyoming--------	0	0	0	18	0	18	1	0	1	0	0	0
Puerto Rico----	0	0	0	0	0	0	0	0	0	0	0	0
Virgin Islands-	0	0	0	0	0	0	0	0	0	0	0	0
Total-----	428	329	99	2,380	957	1,423	870	474	396	442	159	283

Source: NACD Nonpoint Note No. 20 (March 20, 1979).

Table 5B-2.--Nonfederal contributions of funds and services to soil and water conservation programs in fiscal year 1968

State	Conservation practice design and layout	Program direction and information	Soil surveys	Conservation planning and technical programming	Watershed protection and flood prevention projects	All other	Total
	(Thousands of dollars)						
Alabama	79	226	10	97	899	78	1,389
Alaska	----	32	----	1	----	10	43
Arizona	70	50	1	9	128	64	322
Arkansas	176	219	25	86	1,179	254	1,939
California	1,052	612	203	149	7,260	1,084	10,360
Colorado	247	167	2	37	118	414	985
Connecticut	9	33	26	7	649	31	755
Delaware	2	14	4	22	184	152	378
Florida	125	161	36	30	720	171	1,243
Georgia	83	274	1	26	3,034	1,310	4,728
Hawaii	12	31	----	2	224	18	287
Idaho	204	206	30	49	141	324	954
Illinois	172	423	114	43	124	224	1,100
Indiana	188	404	33	43	2,003	459	3,130
Iowa	815	855	107	151	203	754	2,885
Kansas	252	516	6	287	1,554	141	2,756
Kentucky	84	473	66	77	358	234	1,292
Louisiana	390	227	37	115	3,092	494	4,355
Maine	18	134	52	30	122	194	550
Maryland	84	166	45	47	444	708	1,494
Massachusetts	14	154	45	7	591	68	879
Michigan	166	343	70	44	242	44	909
Minnesota	320	165	53	82	109	374	1,103
Mississippi	67	188	21	22	1,704	304	2,306
Missouri	202	215	----	36	429	926	1,808
Montana	191	195	12	47	84	148	677
Nebraska	487	557	16	47	677	446	2,230
Nevada	80	63	16	12	144	72	387

Table 5B-2.--Nonfederal contributions of funds and services to soil and water conservation programs in fiscal year 1968--Continued

State	Conservation practice design and layout	Program direction and information	Soil surveys	Conservation planning and technical programming	Watershed protection and flood prevention projects	All other	Total
	(Thousands of dollars)						
New Hampshire-------	12	27	15	2	419	12	487
New Jersey----------	35	210	47	58	1,870	104	2,324
New Mexico----------	169	194	7	147	72	284	873
New York------------	75	269	113	64	564	2,649	3,734
North Carolina------	503	291	22	125	567	120	1,628
North Dakota--------	78	226	76	41	341	414	1,176
Ohio----------------	572	401	376	182	131	77	1,739
Oklahoma------------	370	508	1	52	4,702	987	6,620
Oregon--------------	359	372	113	68	624	543	2,079
Pennsylvania--------	110	367	224	40	5,951	112	6,804
Rhode Island--------	2	9	----	2	1	1	15
South Carolina------	133	169	50	15	539	290	1,196
South Dakota--------	106	326	63	52	88	177	812
Tennessee-----------	57	286	1	15	486	112	957
Texas---------------	981	1,363	85	265	3,144	859	6,697
Utah----------------	110	109	10	15	166	695	1,105
Vermont-------------	7	66	----	7	21	53	154
Virginia------------	77	105	128	29	336	113	788
Washington----------	211	255	27	33	113	427	1,066
West Virginia-------	43	126	3	39	894	109	1,214
Wisconsin-----------	179	672	152	140	406	223	1,772
Wyoming-------------	115	113	1	11	28	24	292
Caribbean-----------	34	102	----	9	----	214	359
Other---------------	----	100	----	----	----	----	100
Total---------	9,927	13,769	2,545	3,016	47,879	18,099	95,235

Table 5B-3.--Nonfederal contributions of funds and services to soil and water conservation programs in fiscal year 1978

State	Conservation practice design and layout	Conservation practice application	Program direction and information	Soil surveys	Conservation planning and technical programming	Watershed protection and flood prevention projects	Resource conservation and development projects	All other	Total
	(Thousands of dollars)								
Alabama	117	155	725	30	173	465	98	1	1,764
Alaska	3	308	93	65	114	----	----	462	1,045
Arizona	399	1,258	240	32	49	975	111	10	3,074
Arkansas	459	1,616	1,342	73	360	2,439	864	44	7,197
California	1,494	2,659	2,178	32	540	2,757	948	266	10,874
Colorado	401	1,067	476	85	124	210	140	90	2,593
Connecticut	94	149	396	107	138	149	197	68	1,298
Delaware	61	329	382	----	97	1,215	185	32	2,301
Florida	319	200	461	190	77	362	334	----	1,943
Georgia	754	1,608	1,463	41	551	617	588	----	5,622
Hawaii	257	1,389	104	----	92	141	227	1	2,211
Idaho	532	462	502	179	180	73	113	14	2,055
Illinois	639	670	1,185	256	231	529	318	216	4,044
Indiana	851	1,571	1,847	1,050	449	2,881	318	333	9,300
Iowa	1,349	6,128	2,605	622	347	1,049	124	----	12,224
Kansas	431	566	1,266	24	476	1,674	140	97	4,674
Kentucky	207	2,532	1,322	203	144	179	100	93	4,780
Louisiana	317	1,529	1,510	217	366	4,802	185	25	8,951
Maine	173	448	402	253	357	88	559	23	2,303
Maryland	187	2,214	477	3	236	476	146	154	3,893
Massachusetts	24	37	250	5	48	936	332	61	1,693
Michigan	149	211	847	478	234	848	1,207	----	3,974
Minnesota	756	1,170	932	420	440	196	377	----	4,291
Mississippi	258	764	629	2	126	1,872	445	112	4,208
Missouri	540	480	769	138	200	203	120	23	2,473
Montana	517	5,743	1,054	86	594	489	707	24	9,214
Nebraska	671	931	1,894	149	377	2,683	187	1,643	8,535
Nevada	92	149	254	9	62	----	11	40	617

Table 5B-3.--Nonfederal contributions of funds and services to soil and water conservation programs in fiscal year 1978--Continued

State	Conservation practice design and layout	Conservation practice application	Program direction and information	Soil surveys	Conservation planning and technical programming	Watershed protection and flood prevention projects	Resource conservation and development projects	All other	Total
	(Thousands of dollars)								
New Hampshire---	20	370	134	10	25	13	27	1	600
New Jersey------	150	509	815	13	300	873	271	465	3,396
New Mexico------	217	1,059	460	3	76	491	270	6	2,582
New York--------	425	1,155	766	111	312	563	142	----	3,474
North Carolina--	549	981	985	379	236	2,528	188	373	6,219
North Dakota----	93	164	604	390	112	221	42	1,425	3,051
Ohio------------	5,367	425	1,703	867	837	785	509	415	10,908
Oklahoma--------	531	1,299	1,097	----	387	2,461	496	1,045	7,316
Oregon----------	489	1,460	587	127	218	120	598	103	3,702
Pennsylvania----	373	726	2,870	109	490	332	160	----	5,060
Rhode Island----	5	1	18	1	5	----	66	22	118
South Carolina--	118	519	835	125	174	176	297	439	2,683
South Dakota----	118	724	354	183	70	29	66	7	1,551
Tennessee-------	296	444	655	45	120	852	387	81	2,880
Texas-----------	1,290	1,682	3,497	70	991	3,345	966	----	11,841
Utah------------	90	220	208	10	60	227	102	10	927
Vermont---------	13	26	100	50	11	9	32	112	353
Virginia--------	51	80	477	272	61	378	13	57	1,389
Washington------	260	297	528	162	105	85	27	135	1,599
West Virginia---	60	170	744	23	122	2,240	984	120	4,463
Wisconsin-------	632	1,031	1,654	227	935	199	202	231	5,111
Wyoming---------	203	215	191	15	42	95	41	12	814
Caribbean-------	560	3,042	626	----	404	278	160	16	5,086
Other-----------	----	----	100	----	----	----	----	----	100
Total------	23,961	52,942	45,613	7,941	13,275	44,608	15,127	8,907	212,374

for fiscal year 1968, however, all such contributions are listed together under "Conservation practice design and layout" (table 5B-2). Funds and services for all purposes other than watershed protection and flood control increased by as much as three times during the period.

Tables 5B-4 and 5B-5 show the sources of nonfederal contributions of funds and services to soil and water conservation programs in fiscal years 1968 and 1978, respectively. All three sources--state governments, local governments, and private individuals and organizations--contributed nearly equally and at least doubled their contributions.

Tables 5B-6 and 5B-7 show funds appropriated by state and local governments for conservation programs in fiscal years 1968 and 1978, respectively. The 1968 figures show only state funds, but those for 1978 also include locally appropriated funds. Again, it is evident that state and local funding of conservation programs has expanded.

State and Locally Administered Cost-Sharing Programs

Cost-sharing programs in Iowa, Minnesota, Nebraska, and Wisconsin are described below. These are the only states with cost sharing at this time. These programs are administered in full or in part by state conservation agencies and local conservation districts. Funds for these programs come from federal, state, and local sources. The programs are administered in addition to and in cooperation with the Agricultural Conservation Program (ACP) of the Agricultural Stabilization and Conservation Service (ASCS) of USDA.

Iowa's state cost-sharing program was begun in 1973. It is an excellent example of how a state conservation agency and a conservation district can administer an efficient and effective cost-sharing program. Recently, Nebraska, Minnesota, and Wisconsin have followed Iowa's lead and developed cost-sharing programs on their own. These recently developed programs are improving water quality as well as conserving soil.

Iowa.--At least one county in Iowa now has three sources of cost-sharing funds for landowners installing permanent conservation practices. A newly authorized program in Polk County, location of the state capital, will provide $340,000 in county funds for cost sharing with landowners over a 2-year period. The program is administered jointly by the Iowa Department of Soil Conservation and the Polk County Soil and Water Conservation District (SWCD) in cooperation with SCS. Some of the funds will provide two technicians and a part-time clerk to the district. Funds for the Polk County SWCD program are allocated from federal revenue-sharing money received by the county.

The Iowa Department of Soil Conservation continues to provide cost sharing through conservation districts. The funds are appropriated annually by the Iowa General Assembly and channeled through the Department to the districts. Since 1973 the Iowa General Assembly has appropriated $19.45 million for the program. The appropriation for fiscal year 1979 was $4.72 million.

The Department has 4 years to spend each year's funds before the money reverts to the state treasury. Allocations to districts are made on the

Table 5B-4.--Sources of nonfederal contributions of funds and services to soil and water conservation programs in fiscal year 1968

State	State government	Local governments	Private individuals and organizations	Total
	(Thousands of dollars)			
Alabama	168	183	1,038	1,389
Alaska	2	7	34	43
Arizona	41	142	139	322
Arkansas	400	1,028	511	1,939
California	6,002	2,268	2,090	10,360
Colorado	142	133	710	985
Connecticut	694	18	43	755
Delaware	301	40	37	378
Florida	66	700	477	1,243
Georgia	1,222	2,778	728	4,728
Hawaii	11	220	56	287
Idaho	266	106	582	954
Illinois	396	133	571	1,100
Indiana	1,392	790	948	3,130
Iowa	1,011	711	1,163	2,885
Kansas	428	1,320	1,008	2,756
Kentucky	376	365	551	1,292
Louisiana	2,425	969	961	4,355
Maine	199	151	200	550
Maryland	426	900	168	1,494
Massachusetts	742	94	43	879
Michigan	162	334	413	909
Minnesota	342	302	459	1,103
Mississippi	218	1,082	1,006	2,306
Missouri	143	394	1,271	1,808
Montana	132	170	375	677
Nebraska	659	780	791	2,230
Nevada	49	145	193	387
New Hampshire	117	322	48	487
New Jersey	449	1,680	195	2,324
New Mexico	405	93	375	873
New York	2,701	813	220	3,734
North Carolina	224	447	957	1,628
North Dakota	440	527	209	1,176
Ohio	677	451	611	1,739
Oklahoma	1,397	1,558	3,665	6,620
Oregon	396	837	846	2,079
Pennsylvania	1,221	5,240	343	6,804
Rhode Island	9	1	5	15
South Carolina	321	341	534	1,196
South Dakota	230	274	308	812
Tennessee	85	341	531	957
Texas	555	1,908	4,234	6,697
Utah	626	154	325	1,105

Table 5B-4.--Sources of nonfederal contributions of funds and services to soil and water conservation programs in fiscal year 1968--Continued

State	State government	Local governments	Private individuals and organizations	Total
		(Thousands of dollars)		
Vermont-------------	39	38	77	154
Virginia------------	265	277	246	788
Washington-----------	207	430	429	1,066
West Virginia--------	841	193	180	1,214
Wisconsin-----------	406	785	581	1,772
Wyoming--------------	63	19	210	292
Caribbean------------	189	20	150	359
Other----------------	----	----	100	100
Total-----------	30,278	33,012	31,945	95,235

Table 5B-5.--Sources of nonfederal contributions of funds and services to soil and water conservation programs in fiscal year 1978

State	State government	Local governments	Private individuals and organizations	Total
		(Thousands of dollars)		
Alabama	325	575	864	1,764
Alaska	990	9	46	1,045
Arizona	407	979	1,688	3,074
Arkansas	3,145	2,098	1,954	7,197
California	751	5,837	4,286	10,874
Colorado	148	1,002	1,443	2,593
Connecticut	363	446	489	1,298
Delaware	1,097	827	377	2,301
Florida	75	1,054	814	1,943
Georgia	1,194	2,476	1,952	5,622
Hawaii	51	386	1,774	2,211
Idaho	421	392	1,242	2,055
Illinois	622	1,209	2,213	4,044
Indiana	3,399	2,550	3,351	9,300
Iowa	7,315	2,596	2,313	12,224
Kansas	1,011	1,663	2,000	4,674
Kentucky	3,308	566	906	4,780
Louisiana	3,665	2,359	2,927	8,951
Maine	413	688	1,202	2,303
Maryland	518	2,031	1,344	3,893
Massachusetts	552	939	202	1,693
Michigan	1,694	1,524	756	3,974
Minnesota	1,106	2,170	1,015	4,291
Mississippi	476	1,946	1,786	4,208
Missouri	312	536	1,625	2,473
Montana	6,286	1,139	1,789	9,214
Nebraska	1,120	6,458	957	8,535
Nevada	134	169	314	617
New Hampshire	5	109	486	600
New Jersey	197	1,991	1,208	3,396
New Mexico	605	657	1,320	2,582
New York	244	2,187	1,043	3,474
North Carolina	781	4,042	1,396	6,219
North Dakota	1,602	991	458	3,051
Ohio	3,048	2,153	5,707	10,908
Oklahoma	1,297	2,618	3,401	7,316
Oregon	501	1,865	1,336	3,702
Pennsylvania	1,645	1,607	1,808	5,060
Rhode Island	34	60	24	118
South Carolina	1,146	945	592	2,683
South Dakota	74	568	909	1,551
Tennessee	635	1,289	956	2,880
Texas	1,957	4,037	5,847	11,841
Utah	13	297	617	927

Table 5B-5.--Sources of nonfederal contributions of funds and services to soil and water conservation programs in fiscal year 1978

State	State government	Local governments	Private individuals and organizations	Total
		(Thousands of dollars)		
Vermont---------------	205	42	106	353
Virginia--------------	36	977	376	1,389
Washington------------	352	565	682	1,599
West Virginia---------	2,232	1,771	460	4,463
Wisconsin-------------	1,440	2,291	1,380	5,111
Wyoming---------------	96	100	618	814
Caribbean-------------	1,728	1,418	1,940	5,086
Other-----------------	----	----	100	100
Total------------	60,771	77,204	74,399	212,374

Table 5B-6.--Funds appropriated by state governments for conservation programs for fiscal year 1968

State	State soil conservation committee, board, or commission	Direct assistance to soil conservation districts	Watershed protection program			Other conservation activities	Total
			Investigations and planning	Works of improvement	Flood prevention program		
			(Thousands of dollars)				
Alabama--------	84,262	-----	75,000	-----	-----	-----	159,262
Alaska---------	2,000	-----	-----	-----	-----	-----	2,000
Arizona--------	10,000	-----	-----	-----	-----	-----	10,000
Arkansas-------	263,900	162,000	200,000	-----	-----	1,600 1/	627,500
California-----	296,937	23,000	420,911	2,148,500	2,973,300	-----	5,862,648
Colorado-------	48,245	3,515	22,000	3,150	-----	49,400 2/	126,310
Connecticut----	420	13,800	-----	644,690	-----	20,000 3/	678,910
Delaware-------	88,600	31,765	-----	100,000	-----	152,500 4/	372,865
Florida--------	34,712	-----	78,200	-----	-----	-----	112,912
Georgia--------	50,000	50,000	300,000	-----	-----	-----	400,000
Hawaii---------	-----	2,600	10,000	143,000	-----	-----	155,600
Idaho----------	23,500	-----	37,500	-----	-----	122,655 5/	183,655
Illinois-------	16,250	247,500	85,000	-----	-----	-----	348,750
Indiana--------	29,730	20,000	142,500	1,200,000	-----	-----	1,392,230
Iowa-----------	76,200	665,000	50,000	-----	-----	100,000 6/	891,200
Kansas---------	40,777	211,283	120,000	33,500	-----	-----	405,560
Kentucky-------	154,240	74,000	30,000	-----	-----	-----	258,240
Louisiana------	70,370	382,500	140,000	1,700,000	-----	31,130 7/	2,324,000
Maine----------	28,531	20,500	-----	30,360	-----	-----	79,391
Maryland-------	22,681	107,697	15,000	-----	-----	-----	145,378
Massachusetts--	35,000	71,000	10,000	550,000	-----	60,000 8/	726,000
Michigan-------	44,291	70,000	-----	-----	-----	-----	114,291
Minnesota------	57,259	215,000	38,500	-----	-----	-----	310,759
Mississippi----	17,500	-----	188,000	-----	-----	39,500 9/	245,000
Missouri-------	32,450	42,473	90,000	-----	-----	-----	164,923
Montana--------	19,950	-----	50,000	-----	-----	-----	69,950
Nebraska-------	49,314	150,000	286,242	646,499	-----	56,634 10/	1,188,689
Nevada---------	750	-----	-----	-----	-----	16,700 11/	17,450
New Hampshire--	300	2,500	-----	105,455	-----	-----	108,255

Table 5B-6.--Funds appropriated by state governments for conservation programs for fiscal year 1968--Continued

State	State soil conservation committee, board, or commission	Direct assistance to soil conservation districts	Watershed protection program: Investigations and planning	Watershed protection program: Works of improvement	Flood prevention program	Other conservation activities	Total
	(Thousands of dollars)						
New Jersey-----	26,911	43,185	11,220	374,400	-----	16,000 12/	471,716
New Mexico-----	44,000	-----	75,000	-----	-----	180,000 13/	299,000
New York-------	34,435	-----	9,032	391,191	-----	936,200 14/	1,370,858
North Carolina-	35,025	64,496	99,781	50,000	-----	-----	249,302
North Dakota---	17,877	20,762	20,000	45,000	-----	75,000 15/	178,639
Ohio-----------	45,395	257,600	15,100	909,000	-----	331,910 16/	1,559,005
Oklahoma-------	77,150	485,350	270,000	100,000	-----	-----	932,500
Oregon---------	46,194	2,427	65,000	-----	-----	37,910 17/	151,531
Pennsylvania---	93,120	152,220	-----	755,346	-----	220,000 18/	1,220,686
Rhode Island---	700	1,800	-----	-----	-----	-----	2,500
South Carolina-	36,471	83,500	100,000	-----	-----	50,000 19/	269,971
South Dakota---	24,904	66,500	26,700	38,500	-----	7,500 20/	164,104
Tennessee------	5,000	30,000	50,000	-----	-----	-----	85,000
Texas----------	110,389	160,441	150,000	-----	-----	-----	420,830 21/
Utah-----------	4,213	23,509	42,000	8,850	-----	443,430 22/	522,002
Vermont--------	17,200	12,900	-----	31,012	-----	-----	61,112
Virginia-------	9,225	53,225	105,235	16,830	-----	80,000 23/	264,515
Washington-----	49,002	-----	5,000	18,019	-----	52,161 24/	124,182
West Virginia--	40,000	89,835	5,000	278,200	35,000	-----	448,035
Wisconsin------	75,000	72,000	-----	133,500	-----	67,000 25/	347,500
Wyoming--------	37,500	11,250	19,500	-----	-----	2,500 26/	70,750
Puerto Rico----	50	146,884	-----	-----	-----	-----	146,934
Total-----	2,427,930	4,344,017	3,457,421	10,455,002	3,008,300	3,149,730	26,842,400

Footnotes for table 5B-6

1/ Water resources research project.

2/ River basin and snow surveys.

3/ Soil surveys.

4/ Public ditch funds, matching of tax ditch funds, and road and bridge protection funds.

5/ Farm forestry, wildlife assistance, and soil and snow surveys.

6/ Soil surveys.

7/ Cooperative soil surveys.

8/ Study of potential sites for surface water storage.

9/ Soil surveys and forestry work.

10/ River basin planning.

11/ Snow and river basin surveys.

12/ Cooperative soil surveys.

13/ River basin surveys, Plant Materials Centers, and improvement of community irrigation systems.

14/ River basin and water resources planning.

15/ Soil surveys.

16/ Soil surveys.

17/ Cooperative soil surveys and snow surveys.

18/ Soil surveys.

19/ Accelerating soil surveys.

20/ River basin studies.

21/ For 9/1/67 through 8/31/68.

22/ River basin investigations, soil and snow surveys, use of interest free money available for structures on Conservation Operations Program, and state water plan.

23/ Soil surveys.

24/ Soil surveys, snow surveys, and matching of flood control expenditures.

25/ Soil surveys.

26/ Snow surveys.

Table 5B-7.--**Funds appropriated by state and local governments for conservation programs for fiscal year 1978**

State	State conservation committee, board, or commission	Direct assistance to conservation district	Soil surveys	Watershed program: Investigation and planning	Watershed program: Works of improvement	Flood prevention programs	River basin and water resource activities	Resource conservation and conservation development projects	Other conservation activities	Total state funds	Total local funds	Total funds
	(Thousands of dollars)											
Alabama	150	237	3	92	6	0	0	35	3	268	258	526
Alaska	0	0	17	0	0	250	400	0	280	647	300	947
Arizona	9	152	20	102	900	157	0	47	17	287	1,117	1,404
Arkansas	387	415	7	196	2,222	32	5	208	22	2,697	797	3,494
California	185	480	270	5	1,240	0	46	305	5,781	1,249	7,063	8,312
Colorado	87	122	150	5	175	253	8	10	4	482	332	814
Connecticut	0	72	76	0	1,698	0	0	307	0	1,722	431	2,153
Delaware	163	394	0	0	304	0	0	187	0	696	352	1,048
Florida	54	392	460	16	767	0	0	344	11	387	1,657	2,044
Georgia	271	1,777	37	0	1,200	25	15	470	0	1,620	2,175	3,795
Hawaii	0	20	100	0	1,706	0	4	200	0	124	1,906	2,030
Idaho	5	215	196	1	0	1	0	15	0	344	89	433
Illinois	80	388	470	158	1,589	0	27	588	0	784	2,516	3,300
Indiana	164	613	940	170	462	0	0	0	0	1,051	1,298	2,349
Iowa	365	1,576	505	60	0	0	0	0	4,278	6,561	223	6,784
Kansas	97	906	79	147	643	0	0	0	89	1,298	663	1,961
Kentucky	298	550	178	0	0	0	0	9	1,500	2,190	345	2,535
Louisiana	74	659	206	347	1,210	0	0	59	0	2,524	31	2,555
Maine	49	66	10	1	151	0	0	86	3	99	267	366
Maryland	40	765	50	66	512	0	0	189	11	944	689	1,633
Massachusetts	3	119	0	24	658	0	113	404	0	938	383	1,321
Michigan	205	475	206	0	460	0	3	1,211	26	1,287	1,299	2,586
Minnesota	388	4,508	783	0	95	0	252	720	0	5,121	1,625	6,746
Mississippi	37	461	46	36	985	550	0	117	0	384	1,848	2,232
Missouri	133	534	289	303	0	0	0	0	0	921	338	1,259
Montana	119	552	181	82	479	0	365	367	4,495	5,332	1,308	6,640
Nebraska	168	4,771	551	228	2,229	0	197	101	3,595	2,627	9,213	11,840
Nevada	208	20	0	0	0	0	10	0	2	217	23	240
New Hampshire	0	3	15	0	311	0	0	34	0	314	49	363
New Jersey	77	1,189	21	120	3,900	25	0	116	1,437	354	6,531	6,885

Table 5B-7.—Funds appropriated by state and local governments for conservation programs for fiscal year 1978--Continued

State	State conservation committee, board, or commission	Direct assistance to conservation district	Soil surveys	Watershed program: Investigation and planning	Watershed program: Works of improvement	Flood prevention programs	River basin and water resource activities	Resource conservation and conservation development projects	Other conservation activities	Total state funds	Total local funds	Total funds
	(Thousands of dollars)											
New Mexico--------	65	37	39	30	45	0	0	0	301	467	50	517
New York---------	139	1,354	118	0	622	0	293	134	0	590	2,070	2,660
North Carolina----	14	964	492	153	2,823	0	0	138	208	1,031	3,761	4,792
North Dakota------	114	294	380	5	0	0	33	196	0	554	468	1,022
Ohio--------------	274	2,392	790	0	577	0	21	183	0	2,597	1,640	4,237
Oklahoma----------	15	1,144	0	30	620	106	0	280	198	1,401	992	2,393
Oregon------------	3	225	58	16	7	0	0	456	30	148	647	795
Pennsylvania------	400	1,336	100	0	210	0	0	57	0	908	1,195	2,103
Rhode Island------	5	0	3	0	0	0	0	0	0	8	0	8
South Carolina----	256	575	282	53	50	0	0	42	206	1,062	402	1,464
South Dakota------	9	278	204	0	27	0	0	6	15	128	411	539
Tennessee---------	30	790	0	34	579	1	2	73	112	534	1,087	1,621
Texas-------------	540	715	18	90	0	0	0	0	0	1,220	143	1,363
Utah--------------	230	84	49	82	0	0	0	2,520	514	2,000	1,479	3,479
Vermont-----------	1	46	0	0	151	0	0	58	33	152	137	289
Virginia----------	2	250	181	110	752	4	27	1	0	21	1,306	1,327
Washington--------	125	50	121	3	70	0	0	110	13	261	231	492
West Virginia-----	78	274	12	215	2,555	980	82	555	1,341	5,015	1,077	6,092
Wisconsin---------	374	1,415	223	33	645	27	10	140	364	1,142	2,089	3,231
Wyoming-----------	71	38	17	30	16	0	0	351	1	99	425	524
Puerto Rico-------	15	52	0	80	0	0	0	0	0	147	0	147
Virgin Island-----	4	191	0	0	0	0	0	63	0	258	0	258
Total--------	6,580	34,935	8,953	3,123	33,651	2,411	1,913	11,492	24,890	63,212	64,736	127,948

basis of Iowa's Conservation Needs Inventory and are subject to approval of the State Soil Conservation Committee, which is the policymaking arm of the Department of Soil Conservation. The district must obligate its initial allocation before asking for more. Unobligated funds are recalled and reallocated according to requests received. Portions of any given state appropriation are held in reserve for priority work in watersheds above publicly owned lakes or for cost sharing mandatory soil conservation measures required by Iowa's erosion control law.

Districts are also allowed to cost share specified eligible practices also approved by the State Soil Conservation Committee. Applicants must be district cooperators working toward a complete conservation plan before they are eligible to receive funds.

District clerks in each of Iowa's 100 soil conservation districts maintain cost-share ledgers, receive applications from cooperators, and process vouchers for payment by the Department of Soil Conservation. SCS and the Department also help districts design, lay out, and certify conservation practices constructed with state funds.

The landowner cannot be reimbursed more than 50 percent of the actual cost of the project, as calculated by the district staff. The landowner must secure and supervise a contractor and provide copies of paid bills before he can be reimbursed for the completed work.

Minnesota.--On May 27, 1977, Governor Perpich signed an amendment to Minnesota's Soil and Water Conservation Law. This amendment included a cost-sharing appropriation of $3 million for the 2-year period from July 1, 1977, to June 30, 1979. This appropriation was the largest ever granted by the Minnesota legislature for controlling soil erosion, sedimentation, and related water quality problems. Of this total, about $2.4 million was allocated for installing permanent conservation practices directed solely at controlling soil erosion, sedimentation, and related water quality problems. One provision included $300,000 in grants to districts for hiring technicians and $150,000 for hiring administrative personnel.

The Minnesota Soil and Water Conservation Board's cost-sharing program is administered by the districts, which apply to the Board for funds. The Board then awards grants to the districts based on their applications and the Board's priorities. District boards make all local administrative decisions and issue checks in accordance with the rules of the State Board.

The State Board will share a maximum of 75 percent of the cost of any eligible practice. The practices eligible under the program are:

1. Erosion control structures
2. Stripcropping
3. Terraces
4. Diversions
5. Stormwater control systems (waterways)
6. Field windbreaks
7. Animal waste control systems
8. Critical area stabilization

Minnesota's 92 soil and water conservation districts have shown that they immediately need nearly $13 million of cost-sharing funds. As the additional money becomes available, it will be used to correct soil erosion problems in both rural and urban areas. For practices that are eligible under the ACP program, state funds may be used to supplement the $2,500 maximum payment allowable under ACP to cover up to 75 percent of the total cost.

As an example of what this means to a local district, in 1978 Scott County received $39,000 in ACP funds, $32,000 in state cost-sharing funds, $1,300 in state funds for administration, and $1,400 in state funds for technical assistance.

The State Board will monitor the program to ensure that it complies with the intent of the legislation. Subsequent reallocations may be necessary to meet demands and to ensure the most efficient use of state money.

Nebraska.--Nebraska has appropriated $500,000 for fiscal years 1978 and 1979 for cost sharing of water impoundment structures, terraces, terrace outlets, and irrigation water reuse pits. These funds are allocated equally among Nebraska's 24 natural resources districts and administered jointly by the districts and the Nebraska Natural Resources Commission.

In addition to the state cost-sharing program, many of Nebraska's natural resources districts have local cost-sharing programs. Table 5B-8 shows the cost-sharing funds each district budgeted for local programs in fiscal years 1977 and 1978. These districts have budgeted similar amounts for their current programs. These local programs are administered solely by the natural resources districts in Nebraska, but are closely coordinated with those funded by federal agencies and the state government.

The amounts listed in the "Wildlife" column are used to pay landowners for maintaining wildlife habitat areas. Seventy-five percent of this money comes through the Nebraska Game and Parks Commission from hunting fees. The remaining 25 percent comes from district funds.

The funds listed in the "Intergovernmental" column are used for cost sharing on projects with other units of government such as counties and cities. These funds are most commonly used for cost sharing on road construction, although other types of projects are involved.

Wisconsin.--In addition to the ACP program, Wisconsin has two new state cost-sharing programs. Also, at least 10 districts in Wisconsin have local cost-sharing programs using federal revenue-sharing funds. Table 5B-9 summarizes these local cost-sharing programs.

The first new state cost-sharing program is targeted at agricultural nonpoint source pollution (see glossary). Its budget for fiscal years 1978 and 1979 was $265,000. Under this program, a district defines its needs and the "best management practices" (see glossary) for which it wants to provide assistance. The State Board allocates money to the district based on its assessment of the district's expressed needs. The program is administered primarily by districts, although the State Board of Soil and Water Conservation Districts issues cost-sharing payments upon certification by the local districts. The State Board will bear up to 50 percent of the costs.

Table 5B-8.--Cost-sharing programs in Nebraska's natural resources districts in fiscal years 1977 and 1978

Natural resources district	Wildlife	Land treatment	Inter-governmental	Total
Upper Big Blue--------	$30,648	$130,000	$164,600	$325,248
Lower Big Blue--------	20,000	-------	-------	20,000
Upper Elkhorn---------	23,000	10,000	-------	33,000
Lower Elkhorn---------	40,250	150,000	150,000	340,250
Little Blue-----------	42,000	-------	-------	42,000
Upper Loup------------	-------	-------	-------	-------
Lower Loup------------	88,726	-------	-------	88,726
Lewis & Clark---------	28,420	-------	30,000	58,420
Middle Missouri-------	9,130	46,264	-------	55,394
Papio-----------------	5,160	247,697	-------	252,857
Memaha----------------	41,310	-------	138,319	179,629
Upper Niobrara--------	500	-------	-------	500
Middle Niobrara-------	-------	-------	-------	-------
Lower Niobrara--------	7,000	3,000	5,000	15,000
North Platte----------	29,500	-------	-------	29,500
South Platte----------	5,350	-------	-------	5,350
Twin Platte-----------	36,205	-------	-------	36,205
Central Platte--------	49,881	2,000	20,000	71,881
Lower Platte North----	25,000	20,000	-------	45,000
Lower Platte South----	45,000	50,000	144,800	239,800
Upper Republican------	16,000	-------	-------	16,000
Middle Republican-----	40,000	-------	-------	40,000
Lower Republican------	22,000	-------	-------	22,000
Tri-Basin-------------	1,258	-------	-------	1,258
Total------------	$606,338	$658,961	$652,719	$1,918,018
No. of districts-	22	9	7	

Source: NACD Nonpoint Note No. 15 (October 1, 1978).

Table 5B-9.--Wisconsin's county-funded cost-sharing programs for conservation and water pollution abatement (1978)

County/SWCD	Amount	Eligible practices
Crawford	$15,000	Barnyard runoff controls; woodlot fencing.
Dane	50,000	Barnyard runoff controls; streambank protection; terraces; drop structures.
Green	30,000	Barnyard runoff controls; streambank protection.
La Crosse	10,000	Streambank protection.
Lafayette	50,000	Barnyard runoff controls; streambank protection; various field practices; begun in 1974.
Marathon	9,000	Barnyard runoff controls; manure management.
Monroe	0	Not funded in 1978; begun in 1974.
Pierce	25,000	Streambank protection; waterways and diversions.
Richland	10,000	Streambank protection; flood-retention dams.
Trempealeau	0	Program presently inactive; funded at $50,000 annually in 1975 and 1976.

Source: NACD Nonpoint Note No. 15 (October 1, 1978).

The second new state cost-sharing program is the Wisconsin Fund-Nonpoint Source Water Pollution Abatement Program. This program received $1.2 million in surplus state general revenues for fiscal years 1978 and 1979. Practices to control rural and urban nonpoint source pollution are eligible for cost sharing under this program. Wisconsin's conservation districts will implement the program at the local level.

Nonfederal Forestry Contributions

Public and private expenditures in timber management, research, and assistance are at an all-time high of about $2 billion a year. Local appropriations are nearly half of the total. State contributions for timber management research increased from $3 million in 1960 to $30 million in 1976.

Fire management funds spent by state agencies and cooperators increased from $74 million in 1950 to $157 million in 1977 (measured in 1972 dollars). Federal contributions are about 15 percent of the total. Of the more than 1.1 million acres of commercial forest land burned each year in the 1970's, 80 percent was state or privately owned.

Forest insect and disease management budgets increased from $14 million to $18.5 million from 1960 to 1977. Money allocated to private and nonfederal public owners of woodland for this purpose increased from $2.6 million to $10.6 million during this period. Nonfederal contributions averaged about 45 percent of the total. Thus, private and nonfederal public contributions to this program ranged from about $1.2 million in 1960 to about $48 million in 1977 (measured in 1972 dollars).

In 1976, 1977, and 1978, federal payments in the ACP forestry practice program averaged almost $1.5 million annually. Landowners supplemented these payments with more than $600,000 of their own.

Since the inception of the Forestry Incentives Program in 1975, $30.5 million of federal funds have been "matched" by more than $12 million in landowner contributions. In 1978 alone, landowners contributed about $5 million.

The forest industry has regenerated more than 1 million acres of woodland a year since 1975. In addition, in industry landowner assistance programs in the South, 120 foresters from 39 companies help landowners manage their forest. More than 10 companies in the Pacific Coast and Rocky Mountain areas do likewise.

Table 5B-10 shows expenditures by universities for forestry research in fiscal year 1977.

The Natural Resources Division of the Extension Service

There are currently 340 full-time equivalent employees funded by state and county sources in the Natural Resources Division of the Extension Service. In fiscal year 1979, this contribution was valued at $8 million.

Table 5B-10.--Expenditures by universities for forestry research in fiscal year 1977

Type of research program	Amount spent	Research areas
Inventory and appraisal for forest and range	$1,004,162	Appraisal of forest and range resources Remote sensing Biological technology and biomensuration
Timber management	$8,521,602	Biology, culture, and management of forests and timber-related crops Genetics and breeding of forest trees Biological efficiency of forest crops
Forest protection	$4,101,728	Forest insect control Forest disease control Prevention and control of forest fires
Harvesting, processing, and marketing of forest products	$6,196,086	Forest engineering systems Economics of timber production New and improved forest products Markets and marketing of timber and related products Forest products, grades, and standards Supply, demand, and price analysis Housing
Forest watersheds, soils, and pollution	$2,979,679	Appraisal of soil resources Soil, plant, water, and nutrient resources Conservation and efficient use of water Watershed protection and management Protection from harmful effects of pollution Alleviation of pollution and disposal of wastes
Forest, range, wildlife, fisheries habitat development	$2,210,663	Improvement of range resources Fish and wildlife

Table 5B-10.--Expenditures by universities for forestry research in fiscal year 1977--Continued

Type of research program	Amount spent	Research areas
Forest recreation and landscape values	$1,514,041	Outdoor recreation Trees to enhance rural and urban environment
Alternative uses of land	$788,214	Alternative uses of land Multiple use and evaluation of forest programs
Technical assistance	$55,134	Technical assistance to developing countries Improved income in rural communities

References

National Association of Conservation Districts. 1978. Nonpoint notes on 208 implementation. No. 15, October 1, 1978, Washington, D.C.

National Association of Conservation Districts. 1979. Nonpoint notes on 208 implementation. No. 20, March 20, 1979, Washington, D.C.

Chapter 6 - Developing Soil and Water Conservation Strategies for the 1980's

This chapter discusses components of a comprehensive program for achieving the soil and water conservation objectives identified in the RCA process. It also discusses how these program components and the conservation objectives can be combined into alternative strategies that USDA can use to meet soil and water conservation challenges in the future.

A soil and water conservation program must be flexible enough to address the diverse physical, social, and legal conditions throughout the Nation. Different climatic and physical conditions present different conservation problems. A conservation program must take into account diverse local units of government, property laws, water rights, tax administration, and zoning and other land management techniques. It must also allow for changes in the relative profitability of foreign and domestic markets and specific crops, equipment, pesticides, irrigation, and other technology.

The Need for a Public Program

Two-thirds of the Nation's lands are privately owned; the primary responsibility for managing these lands lies with private individuals. The public, however, has an interest in the conservation of private lands and in minimizing adverse offsite effects of activities on private lands. Problems that may extend beyond one landowner's property to affect others--pollution, flooding, disturbed wetlands, the removal of prime farmland from production, and so on--are generally accepted as legitimate concerns for public action.

Land managers who know about conservation measures will implement those measures that reduce costs, increase income, or add to the value of their lands. Many conservation measures, such as reduced tillage and increased water and energy efficiency in irrigation, are profitable for the farmer. The practices that pay vary from place to place depending on climate and crops. In addition to practices that pay, many land users implement other conservation measures that are normally accepted as part of good land management in their area, even if these measures do not provide a net monetary return. For example, according to a study by Cornell University, on rented land farmers usually implement only conservation practices that pay in the short run. On their own land, however, these farmers implement practices that do not pay in the short run but may pay in the long run.

Historically, the land user's awareness that conservation pays has been the starting point of USDA programs. USDA soil and water conservation programs have encouraged land users to continue with and expand on voluntary conservation measures by providing information, education, loans, cost sharing, and technical assistance. Alternative strategies chosen to meet the challenges of the future will use many existing USDA services and incentives.

Normal market conditions and a USDA program of information, education, and technical assistance are adequate to meet many but not all objectives for soil and water conservation. There are conservation problems that private land users do not have adequate profit incentive to address. Special efforts are needed to solve these problems.

The problems most likely to need additional USDA attention are those that have offsite and long term effects. In such cases, the land user often cannot collect the benefits from investing in conservation and therefore has little incentive to adopt conservation measures. By directing USDA programs and other programs specifically to these problems to provide the services and incentives needed, the public could induce conservation management.

In directing resources to a specific problem and objective, the following considerations are important:

1. What is the conservation objective worth to society?
   The benefits of conserving a resource must be greater than or at least equal to the cost of conserving it. In deciding whether or not the benefits outweigh the costs, however, society's considerations differ from an individual's. The discount rate to society, applied to future benefits and costs, may be much lower, perhaps even zero. The time horizon may be 50 to 100 years or more away. Because of risk, uncertainty, and a desire to avoid irreversible changes in resources, society may be willing to protect some resources that seem to be of very low current value.

2. What level of subsidy or regulation is fair?
   A subsidy should be just enough to make the practice profitable to the individual. If conservation were achieved through regulation, the land user might suffer an income loss and thus reduced asset values where the market is responsive to private interest rates and profits from farm production. Who pays what and for what benefit is an important part of what is equitable. It must be carefully evaluated case by case.

Program Planning

Steps in Program Planning

Program planning defines objectives and identifies ways in which resources and efforts can be directed toward attaining those objectives.

Setting Objectives.--The first step in designing a program is working out a set of objectives that land users and various levels of government are willing to support. These objectives are not independent of programs: the cost and acceptability to the public of a program determine whether or not the public is willing to recognize resolution of a problem as a program objective. For example, weather is a great problem in agriculture, but very few people now recognize weather control as an immediate goal. The resources that would be required to solve the problem are too vast and the results too uncertain to be included in any feasible program. In addressing smaller problems, we may also be confronted with too high a price to justify solutions.

The conservation objectives of all potential participants in a soil and water conservation program--federal, state, and local governments, interest groups, and individuals--are based on the attitudes of these participants toward conservation and their perceptions of the future, risk, profitability, and

the need to protect soil and water resources. The objectives set by participants vary according to their assets and perspectives. National objectives tend to be long term and oriented to offsite effects; individual goals are more likely to be short term and directed toward private gain. States and local communities have intermediate goals that are broader than an individual's but narrower than the Nation's. Since any soil and water conservation program must be acceptable to all participants, conservation objectives and programs to achieve them must recognize this diversity of interest.

Individual land users have a goal of achieving a profitable level of conservation. However, many also have great concern for soil, water, plant, and wildlife resources.

States and local communities have conservation objectives and programs established through state laws and local ordinances. Examples are programs to regulate erosion control at construction sites and to protect water storage reservoirs from sedimentation. The willingness of states and local governments to support the objectives set in a national soil and water conservation program will depend to some extent on who is expected to finance the program.

Proposed national objectives for seven potential problem areas have been identified in the RCA process. These potential problem areas have been identified on the basis of the soil and water resources available, the capability of those resources, and the demands placed on those resources. The potential problem areas are: (1) Soil Resources: Quantity and Quality for Food and Fiber Production; (2) Water Quality; (3) Water Supply and Conservation; (4) Fish and Wildlife Habitat; (5) Upstream Flood Damages; (6) Energy Conservation and Production; and (7) Related Natural Resources, which includes agricultural use of organic wastes and soil and water management in urban and urbanizing areas.

In addition to setting objectives for soil and water conservation, priorities must be set with respect to the importance of meeting each objective. Individuals and different levels of government may view these priorities differently, so a set of reasonable compromises must be worked out.

<u>Analyzing Constituent Elements</u>.--After setting general objectives, the second step in program planning is to break these objectives down into specific and measurable terms. What actions will be needed in order to achieve the objectives? What behavior is needed from land users? Answers to these kinds of questions influence government's role.

<u>Designing Delivery Mechanisms</u>.--The third step in program planning is designing a delivery system that will induce land users to undertake actions that will achieve the desired objectives. This step involves choosing a mix of services (information, education, technical assistance) and incentives or disincentives (cost sharing, cross compliance, taxation, regulation, loans, grants).

Organizational and institutional arrangements must provide the delivery mechanisms needed. Choices must be made about who carries out programs, who finances them, and what structure will be used for the program. In some cases, new organizations may be needed. In other instances it may not be

possible to make significant changes in present organizational structures. The delivery mechanisms chosen would then be designed to work within the existing organizational structure.

Allocating Public and Private Resources.--The fourth step in program planning is allocating resources among delivery systems in accordance with the resources available and the effectiveness of each delivery system in meeting objectives.

Monitoring, Evaluation, and Research.--Monitoring, evaluation, and research are also necessary components of a soil and water conservation program. Monitoring and evaluation continually assess changes in resource conditions and examine the effectiveness of current programs. Monitoring and evaluation require (1) techniques to measure changes in the condition of the resources and program output, (2) adequate capacity to collect data, and (3) knowledge of the relationship between the outputs and the achievement of objectives. As programs succeed or fail in meeting conservation objectives, evaluation will help managers decide how the programs should be modified. Research identifies new technology or better means of solving resource problems and seeks solutions to new problems as they arise. Anticipating new problems in time to have effective solutions available is extremely difficult.

Approaches to Program Planning

USDA could design a program to address national concerns, local concerns, or something in between. In the first approach discussed below, USDA would develop programs that meet national objectives; in the second, it would plan programs around objectives identified by local people as having high priority. Regardless of the approach, the success of any program depends on the amount of conservation applied by private individuals.

A Nationally Determined System.--A nationally oriented program might use the conservation objective levels determined in the RCA process and in national level analyses and program evaluations to allocate federal resources among various regions and problem areas. The conservation objective levels determined under RCA for the potential problem areas would provide the bases for determining the critical needs requiring national attention. Support activities, such as soil mapping, resource inventories, and monitoring, and much of the budget for traditional soil and water operations would be based on national analyses and evaluations. Innovative test programs could be applied to existing problems.

To implement a nationally determined program, USDA agencies would need a common, well defined set of objectives for soil and water conservation. This approach relies heavily on sound analyses based on good data, and would therefore work best on the potential problem areas for which the basic physical and economic relationships are understood and for which data have been collected over an extended period. The objective levels for the soil quantity and quality, water conservation, and upstream flood damages potential problem areas were based on greater amounts of adequate data and analysis than were the objective levels for the other potential problem areas. USDA has collected data on controlling soil erosion, on water conservation on irrigated lands, and on flood damages in small upstream watersheds for many

years. These data provide a relatively sound basis for a nationally determined program.

A Locally Determined System.--A locally determined program would be based on the assumption that the delivery of soil and water conservation programs is more cost effective and better focused on priorities if planning and decisionmaking occur at the local level. Such a program could have the advantage of working through local governments in urging land users to participate. Groups at the state and local level would identify critical problems, cost effective solutions, and priorities. This strategy would focus on county or multicounty units, such as watersheds, river basins, or regions, that have common conservation problems. Multidisciplinary analyses of an area's resources, needs, and environment would identify problems and suggest economic models that could be used to develop cost-effective solutions.

Local and national perceptions of problems and objectives could be more easily reconciled during local planning if USDA issued policies to guide and help local program planning. Such guidelines would reflect national perceptions and priorities. National policy guidelines, however, may not be enough to ensure that national conservation objectives would be met under a locally determined approach.

In addition to the separate approaches--national or local determination of program planning--intermediate mixes are possible. If planning originates at the local level, there might be more local interest in evaluating conditions, identifying problems, and formulating programs than if the program were designed at the national level. On the other hand, if planning originates at the national level, more diffuse interest groups might have greater roles in program planning. Such groups could concentrate their resources at the national level to more effectively influence policy. In either approach, opportunities exist for special interest groups to become involved.

Where program planning takes place may also influence which delivery mechanisms are considered. Although individuals may be reluctant to accept financial responsibility for cost sharing or to urge increased taxation on nonconserving land users, state and local governments may be willing to accept greater responsibilities. The historical tools and strengths of the various levels of government may affect their willingness to recommend specific program strategy alternatives.

Administrative and Organizational Proposals

The Department of Agriculture can arrange its programs and personnel in various ways to achieve soil and water conservation objectives. Three organizational structures are being considered in the RCA activities. The structures differ in the ways objectives are set, programs are developed, and responsibilities are assigned. These structures are: (1) modifying the existing system; (2) reassigning roles by functions; and (3) forming one agency--a Soil and Water Conservation Agency.

In comparing the three organization and institutional arrangements, the following questions are important:

1. How responsive is this arrangement to USDA priorities?

2. Are the conservation objectives common to all USDA agencies under this system?

3. How well coordinated between agencies are evaluation, monitoring, and budgeting activities?

4. How difficult will it be to adopt this arrangement?

5. How quickly can the system be implemented?

6. How are agency roles changed by this arrangement?

7. How will the change affect land users, interest groups, and state and local governments?

8. How will relationships between USDA and other federal authorities change?

9. How will this arrangement affect USDA's ability to conduct research and disseminate the results? Will the effects on research and development programs be good or bad? Will it be possible to maintain a professionally trained force, given changes in career opportunities?

Modifying the Present System

This alternative assumes that there is nothing basically wrong with the present organization of the Department. In a fine-tuned version of the existing system, all USDA agencies would retain their present missions and responsibilities. The major change would be the establishment of procedures to set common USDA soil and water conservation objectives and to avoid duplication among programs. There would also be changes in program evaluation and in administration.

An interdepartmental coordinating committee would be established for all soil and water conservation activities. It would set USDA priorities. This committee would provide the national direction for soil and water conservation programs. It would provide the framework within which state and local groups would develop their own programs.

At the state level, the present USDA State Coordination and Administration Committees would be responsible for coordinating development of USDA programs. They would provide the direction needed to formulate USDA programs at the county or multicounty level within national guidelines.

Improved coordination among the agencies could produce a more cost-effective USDA program. Departmental objectives could be met that might not have even been identified in an agency-by-agency approach. The programs might be more responsive to overall national objectives and less subject to single-interest constituencies. Programs could be directed to specific problems to help meet national objectives. An excellent example of this unified approach already in use is USDA's Model Implementation Projects, which are directed primarily

to communitywide water quality problems. In the Model Implementation Projects, USDA uses delivery services and incentives together in helping land users improve water quality.

Because agencies would retain their identities under this proposal, individuals, organizations, special interest groups, and local governments would still have satisfactory access to those organizations they traditionally work with, but the public would see a more unified Departmental approach to handling soil and water problems.

The cooperative effort should facilitate identification of research needs and transfer of technology to land users. Cooperation should also make it easier to maintain a professionally trained work force. Interagency program planning at all levels would expose agency staff to more and different agency operations and foster a better understanding of the need to focus all USDA efforts on common objectives.

Few changes would be needed to implement the fine-tuned system. No change would be needed in the Department's basic authorities. All that would be needed is agreement as to what each agency would do and policy guidance at the Departmental level. The system could be operational by 1982.

Reassigning Roles by Function

Under this organizational alternative, the soil and water conservation functions of various USDA agencies would be reassigned to a single most "logical" agency. All technical assistance for soil and water conservation would be assigned to the Soil Conservation Service (SCS); all grant, contracting, and cost-sharing assistance would be administered by the Agricultural Stabilization and Conservation Service (ASCS); all loan services, by the Farmers Home Administration (FmHA); all information and education activities, by the Science and Education Administration (SEA)-Extension Service; and all research, by SEA-Agricultural Research, SEA-Cooperative Research, and the Economics, Statistics, and Cooperatives Service (ESCS). The Forest Service (FS) would continue to provide leadership for forestry.

Such an organizational arrangement would make coordination among USDA agencies, as described in the "modified present" system, even more important. All agencies would still work toward a common Departmental objective. Program evaluations would be better coordinated. This alternative also would include the creation of a USDA coordinating committee at the national and state levels.

There are certain advantages to this alternative, especially if there is expanded USDA agency colocation of county offices with shared resources. The main advantage would be improved public services and a clearer understanding of who provides what kind of services. Contacts by state and local governments with USDA agencies would be simpler.

There are some disadvantages to a functional role approach. Land users would still have to go to different USDA agencies to obtain assistance. Coordinating assistance from two or more agencies could be more difficult. Because conservation measures are applied seasonally, timeliness of joint assistance frequently is critical.

There may also be other disadvantages. This organizational structure might reduce career opportunities and complicate the maintenance of a professionally trained work force to provide the necessary services to the public. The "modified present" system would permit horizontal and vertical movement among agencies, but the functional role alternative would pigeonhole people into specialties.

Establishing a Soil and Water Conservation Agency

This organizational alternative provides for the creation of a completely new agency. It would be made up of the 34 soil and water conservation program activities of the six USDA agencies that administer these programs: ASCS, ESCS, FmHA, FS, SCS, and SEA.

Under this alternative, the relationships with the states might be somewhat better than if roles were reassigned by function. Traditional lines of communication between state agencies and USDA could be maintained. Special interest groups would still have access. The more unified Departmental approach to handling soil and water conservation described under "Modifying the Present System" would also be possible under this alternative.

The coordinated program planning approach should be as effective in identifying research needs and transfering research technology under this alternative as under the other alternatives.

Opportunities for achieving the objectives for each potential problem area would be enhanced by the centralized approach. When desired, a federal presence could be provided at the state and local levels to help carry out national objectives. However, there would still be duplication of effort under this approach. For example, expertise for administering soil and water conservation loans would be needed within the Conservation Agency. Other agencies would also need espertise for administering other USDA loans (low income housing, grain loans, etc.)

Changing Intergovernmental Relationships

In addition to changes in organization within USDA, changes in the relationships between various levels of government have been considered. While some change in the relationship between USDA and other levels of government is implicit in all three alternatives for organizational structure, more direct and intentional changes are also possible. Two proposals for change are (1) an increase in the state role in conservation programs and (2) a focused multicounty (regional) approach.

Increasing the State Role

The states could be given a larger role in establishing objectives and priorities as to the level and mix of conservation programs through federal grants to states. The states could also accept increased responsibility for financial and staff support of the program. If states took a larger role in designing programs, they could expect to assume greater responsibility for carrying them out.

Increasing the state role would be particularly feasible with respect to the water quality, fish and wildlife habitat, and water conservation and water supply potential problem areas. The states have experience in dealing with water pollution. In the West, states have long had responsibility for water rights. States have also historically had responsibility for fish and wildlife.

Where federal, state, and local public funds are made available for soil and water conservation, these funds would be used for meeting national objectives and state and local needs. Federal funds could be directed mainly to meeting long term national objectives. USDA would provide to local and state governments the organizational, technical, and management training and the cost sharing and technical assistance needed to implement a soil and water conservation program. The way in which this strategy would be implemented could vary from state to state. Implementation could be expected to take place faster in the states that have already assumed a role significant in soil and water conservation.

Changes in the relationship between USDA and the states are already evident in the vigorous state conservation programs in Iowa, Minnesota, Nebraska, Ohio, and Wisconsin.

A Multicounty Regional Approach

In a multicounty regional approach, resource problems would be addressed at this level. State and multicounty groups could identify critical problems, cost-effective solutions, and multiagency program priorities. Grouping counties having common resource problems--perhaps by watershed boundaries--could allow USDA to concentrate on the most important problems and tailor programs to the region's needs. State and local governments, land users, and USDA agencies would cooperate in setting priorities for various program elements. Priorities could reflect a blend of national and local objectives.

Under a multicounty regional approach, USDA could focus programs on regions with special needs and on regions with demonstrated capacity for assuming regional responsibility. Focusing resources in this way might increase the cost effectiveness of USDA expenditures.

The upstream flood damages, water quality, water conservation and supply, and soil resources potential problem areas, which affect an area, a watershed, or a river basin, could be addressed using a multicounty regional approach. These problems involve many land users and their solution provides offsite and public benefits.

Service Delivery Mechanisms

Service delivery mechanisms are program components that provide technical services and information assistance to help land users adopt soil and water conservation measures. These services improve the land user's knowledge and acceptance of and ability to use conservation practices.

Qualified specialists provide information and education to help groups and individuals identify their problems, evaluate alternatives, and make choices in their use of soil, water, and related resources. Education would include

information through public meetings, tours, printed materials, electronic media, short courses, and workshops and in other ways.

Qualified soil conservationists, agronomists, soil scientists, engineers, foresters, and others provide technical assistance to help individual land users, groups, or units of state, local, or federal government plan or apply practices for conserving soil, water, and related resources.

Service delivery addresses who provides technical and information or education personnel, who pays them, and who directs their work. These aspects are closely related. The service delivery arrangement could be completely federal, and all personnel could be employed and paid by the federal government and directed to meet national objectives and priorities. It could be completely state or local, and all personnel could be employed, paid, and directed by state or local authorities. In an intermediate position, state and local personnel could respond to federal priorities and be paid with a mix of state, local, and federal funds. Federal personnel could be located as needed in each local office in accordance with an agreement between the federal government and the state or local jurisdiction.

Mechanisms Now in Use

Technical assistance and information and education are now provided by a mix of federal, state, and local funding. The relationship between federal and local or state responsibility for staffing service delivery systems differs between USDA agencies, and even within some agencies. For example, in most states, technical and financial assistance is provided mainly by federal employees, through the use of federal funds. In some states, however, a significant number of employees who provide such assistance are state or local government employees paid with nonfederal funds.

Technical assistance and information assistance on state owned and privately owned forest lands is provided by personnel employed by state forestry agencies under the direction of state foresters, using federal and nonfederal funds, with guidance from the Forest Service. Their research activities also provide for the transfer of technology to state forestry agencies and to land users.

Federal personnel provide technical assistance in developing management plans to enable land users to repay farm operating loans, including soil and water conservation loans, obtained through FmHA.

SCS provides technical and financial assistance to individuals and units of government. It mainly provides technical assistance in planning and applying soil and water conservation measures.

SEA-Extension provides information and education and technical assistance primarily through county offices and the land grant universities. Some of the funding is federal (the proportion varies from state to state). General federal program guidance is provided. At the local level, the state and counties provide funds for extension activities.

ASCS provides financial, information, and administrative services through state and local committees. The federal government provides funding for both

state and local committees, but the employees at the local level are hired locally and the state staffs are federal employees.

SEA and ESCS research activities for soil and water conservation provide the base for USDA technology transfer to land users. Funding for research is provided through federal and state appropriations.

The variety of options currently in use demonstrates some of the possible alternatives. Variations of these options could be used for all potential problem areas.

Program Delivery Mechanisms

Program delivery mechanisms are those program components designed to implement soil and water conservation programs by using incentives for and penalties to land users. These mechanisms include contracting, cross compliance tied to related programs, taxation, provision of grants, cost sharing, and loans, and regulatory actions.

In choosing among delivery mechanisms, the strengths, weaknesses, and applicability of each approach to meeting the conservation objectives must be considered. Generally speaking, programs that provide incentives are far more acceptable to land users than programs that impose penalties. However, some problems might be more effectively solved through penalties than through added incentives. When relatively severe penalties are called for to protect a critical resource, a majority among the affected public must understand why such penalties are needed and must support them. Similarly, when rewards and penalties are distributed in different amounts among different people, the rationale for these differences must be clear to the public. In most instances, several mechanisms will be used. A program of cost sharing and grants may be supported by a regulatory authority and administered through a joint federal-state-local effort.

Figure 6-1 illustrates the choices available among program components. The segmented lines represent the range of options available in program planning, service and program delivery mechanisms, and evaluation systems. A soil and water conservation program can be conceptually described on these continuums by choosing a point on each line which represents the preferred option for a given program component. A profile formed by connecting a point from each line designates the mix of program components. Those components not applicable to a given option would not be connected in order to signify that it is not a component within that option. The diversity of options is suggested by the large number of possible profiles. A program might consist of national or local program planning, federal or state responsibility for personnel and financial support of service delivery mechanisms, contracting or no contracting, regulation or no regulation, and so on. Figure 6-1 can be used to display possible combinations of these choices. The degree of conflict that may exist between various delivery mechanisms and other program components must be considered when developing alternative program strategies for soil and water conservation.

Five program delivery mechanisms are described below. The range of ways each option could be used and the advantages and disadvantages of each are discussed.

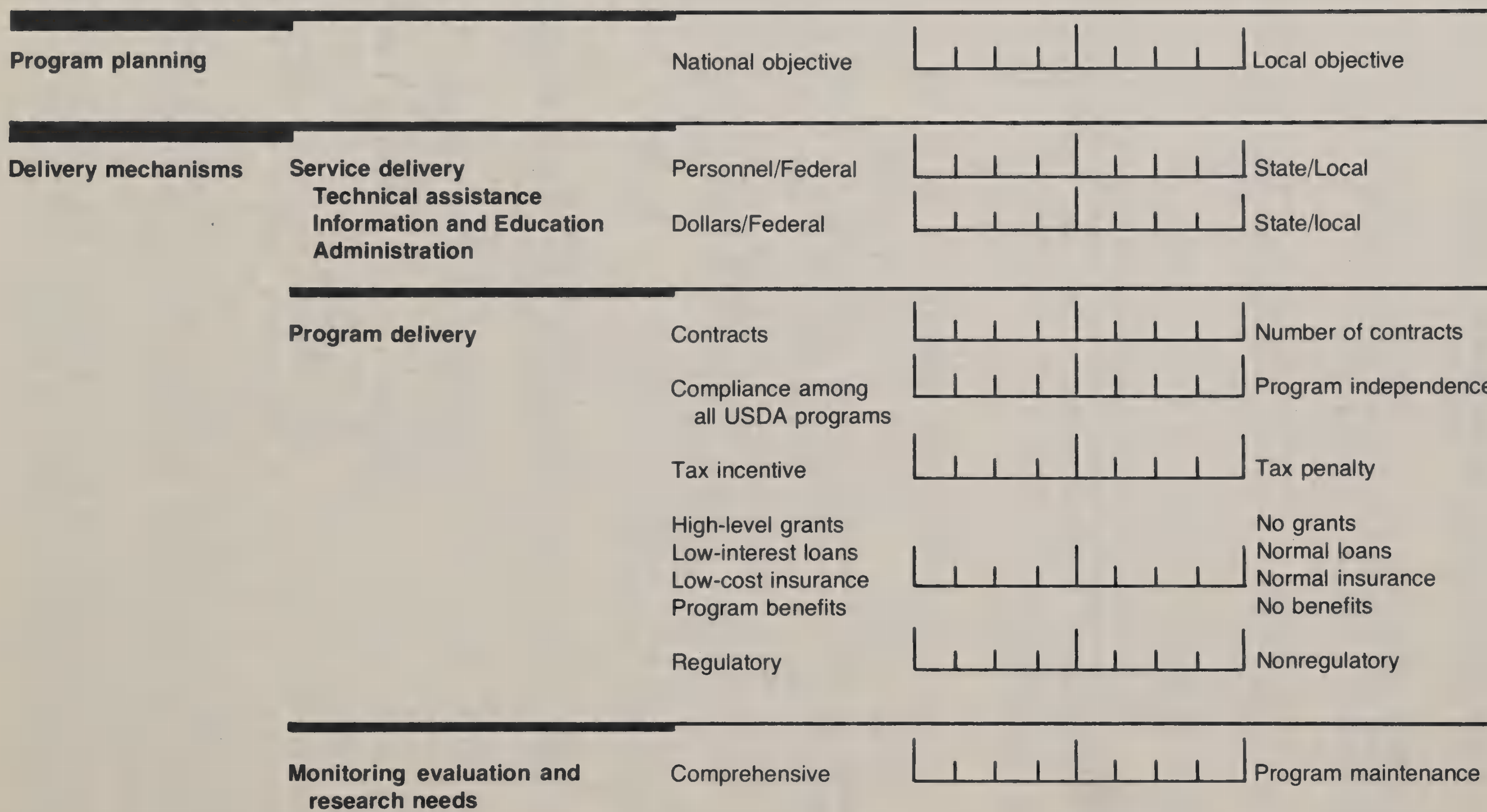


Figure 6-1.--Choosing among program components.

Contracting

A contract would specify that a land user adopt or maintain a certain level of conservation in return for specified contributions from the Department. Multiyear contracts would be advantageous both to land users and USDA. For the land user, a contract would ensure that support would remain at an agreed upon level through the period of the contract. For the Department, it would ensure that conservation measures would remain in place over the period of the contract.

In using contracts, several factors should be considered:

1. The contract can be directed to a specific problem area where other conservation programs have been ineffective. It can also be used to ensure that payments and services from the Department are given only to land users with priority needs. Proper incentives can be given because each individual case will be considered on its merits, and the benefits offered through a contract can be adjusted to the level of costs required from the land user.

2. Both the government and the land user enter voluntarily into contracts. If contracts are going to be effective, the rewards they offer must be sufficient to encourage participation.

3. Contracts could include landowner "buy out" clauses. If market conditions change and either the government or the land user finds it unprofitable to continue with the arrangement agreed upon, the contract can be modified. Rather than simply plowing up permanent plant cover in order to farm a larger acreage when prices rise, a land user under contract would contact USDA and arrange to modify the agreement. Modifying the agreement might include repaying cost shares received for installing conservation measures, paying a penalty, or arranging for installation of other needed conservation measures for cropland. USDA would be able to make adjustments to changed demands for food and fiber production. If the benefit to society of retaining the practice exceeded the potential gains to the land user of changing the land use, the Department would also have an opportunity to raise the benefits granted under the contract in order to keep the practice in place. A provision for land retirement could also be included.

4. Contracts could be written in terms of a performance standard (per ton soil loss reduction) as well as in terms of specific practices, encouraging a land user to find the least-cost solution to the problem addressed.

5. Administrative costs of long term contracts are higher than those associated with short term contracts. Revising contracts and monitoring the performance of contractees would require additional personnel. However, long term contracting would give more assurance that conservation measures would be operated and maintained properly.

Contracts would be used for all the potential problem areas in dealing with individual land users. Contracts would be especially suited where erosion problems on individual farms need attention. Contracts have also been used for improving water quality, for water conservation, and in preserving wetlands for fish and wildlife habitat.

Cross Compliance

USDA could require that land users meet a certain conservation standard of performance or carry out certain conservation measures in order to qualify for USDA program benefits. The Department might remove all program benefits from land users who fail to comply or might offer special additional benefits and subsidies to individuals who do comply. The absence of compliance requirements would simply mean that a land user's soil and water conservation behavior was not a factor in determining eligibility for USDA program benefits. The range of rewards that could be offered in exchange for compliance is discussed in detail in the part of this chapter dealing with loans, cost sharing, grants, insurance, and other program benefits. Briefly, the benefits might include subsidized interest loans, crop or flood insurance adjustment, commodity payments, and payments for income foregone or for maintenance of conservation practices.

Under a cross compliance program, USDA would have to determine which programs could be most successfully linked to conservation behavior, would have to determine the requirements a land user would have to meet in order to comply, and would have to monitor land users to certify that they had complied with the requirements.

In considering which programs might be tied to soil and water conservation activities, USDA should consider both the attractiveness of the program benefits to potential participants and the impact of compliance requirements on participation in the conservation program. For example, commodity support programs help to ensure farmers and ranchers a fair return from their investment and help to protect them against market fluctuations. Cross compliance could require producers participating in these programs to also carry out a program of soil and water conservation. Cross compliance between conservation programs and commodity programs involves combining long term and short term objectives. These objectives may be in conflict. Commodity programs require year-to-year flexibility, while conservation programs have both immediate and long-term dimensions. Cross compliance would probably be most successful where program benefits are directly related to the particular problem areas that the program is attempting to address. For example, to be eligible for housing loans to build flood-proof structures, a land user would have to comply with appropriate standards for use of flood plains.

Monitoring cross compliance requirements would vary widely. If compliance consisted of maintaining a certain water quality, monitoring would be technically and administratively complex and very expensive. The frequency of monitoring and the degree of complexity of standards would determine both its cost and effectiveness.

Loans, Cost Sharing, Grants, Insurance, and Other Incentives

Loans, cost sharing, grants, and insurance are among the financial incentives that the federal government could use to deliver soil and water conservation programs. The level of cost sharing would vary according to how critical the need is to meet identified objectives. A high level of incentives might provide cost sharing, including compensation for income foregone, land retirement, or maintenance of conservation practices; conservation loans below regular interest rates; and crop or flood insurance at below-market rates. The lowest level of incentives might provide no cost sharing by the government, availability of conservation loans only through traditional market sources, and crop or flood insurance only through private firms and at actuarially determined rates. An intermediate level might provide partial cost sharing for annual out-of-pocket expenses, moderately subsidized loans, and moderately subsidized insurance.

Financial incentives can be offered directly to individual landowners, land users, groups, or governments undertaking soil and water conservation efforts. USDA financial incentives to individual land users have generally been offered as partial cost shares for out-of-pocket expenses and have emphasized "permanent" conservation practices.

USDA agencies have historically used grants, loans, and cost shares, which are readily accepted by land users. When these incentives are tied to a compliance condition or contract or are offered to help land users meet regulatory standards, they can be very precise.

Loans and cost sharing could be used in meeting objectives for improvement in soil quantity and quality, water quality, water conservation and supply, and fish and wildlife habitat. Some states provide a revolving loan fund and also provide funds for project-oriented activities, such as reducing upstream flood damages in rural communities.

Taxation

Taxation could be used as either an incentive or a penalty. For example, taxes could be reduced in proportion to the land manager's investment in conservation. Property taxes could be reduced on land where adequate conservation measures were in place. These tax measures could be administered in conjunction with federal, state, or local taxes. In designing a soil and water conservation program that called for changes in state and local taxes, for example, the federal government could provide grants to state and local jurisdictions for revenues foregone. Differences between states and localities with respect to both income and property taxes, however, could make it difficult to implement an equitable program nationwide.

The information needs for a system of tax rewards would be less rigorous than the information needs for a system of penalties. Justifying the awarding of a tax break is easier than justifying the imposition of additional tax liability. Taxing could be used as an incentive for the soil resources potential problem area. Many states now provide tax incentives on private forest land where long range benefits accrue from that forest.

Regulation

Regulation can also be used as a delivery mechanism for a soil and water conservation program. This approach could be used as a backstop for those objectives the country most wishes to achieve, such as improving water quality in lakes and streams.

Regulations assert that the land user has a legal responsibility to manage his resources in a certain manner. This contrasts with the current attitude toward most conservation: while the land user is encouraged to adopt conservation management, he may in most cases use the soil and water resources as a property right. Exceptions to this rule include regulation of sediment problems at construction sites and the "beneficial use" requirements of water laws in the western states.

A regulatory system for conservation problems would provide increased control over the behavior of land users and increased ability to address specific problems. Disadvantages of this system could include a reduction of rights for land users, added enforcement and monitoring costs, and possibly destruction of enterprises that are small or have limited resources and that cannot comply with the regulations.

This approach would be most applicable to the water quality, upstream flood damages, and soil and water management in urban and urbanizing areas (related resources) potential problem areas. There are already significant regulations in force for these problem areas.

Chapter 7 - The Data Base on Soil and Water Resources

Section A-Documentation of National Resource Data in the 1980 RCA Appraisal

Procedure

The National Resource Inventories (NRI) (USDA, 1978b) provided much of the data used in preparing the 1980 RCA Appraisal. For the NRI, the Statistical Laboratory of Iowa State University selected random sample areas known as primary sample units (PSU's) for each county in each state. Most PSU's in midwestern, western, and southern states were 160 acres; most in eastern states were 100 acres. Some were as small as 40 acres and some as large as 640 acres.

Three points were selected at random within each PSU (only two points were used in PSU's of 40 acres). The Soil Conservation Service (SCS) examined about 200,000 sample points in the field and compiled data for the NRI. SCS field specialists and technicians collected the data. State SCS staffs and the Iowa State University Statistical Laboratory made quality control checks. SCS reexamined more than 6,000 sample points in the field for correctness, and the Statistical Laboratory made other special computer checks for consistency.

County Base Data.--Basic data about the gross area of each county and the net area of land and water in each county were obtained from the U.S. Department of Commerce, Bureau of the Census. Estimates from the 1970 Census were provided to SCS field offices. Field personnel reported any changes in land and water areas between 1970 and 1977. Such changes might have been caused by county boundary changes, construction of large reservoirs, or other activities.

The Forest Service reported land it administered as National Forest System or National Grasslands, and the Bureau of Indian Affairs reported the acreage of land it administered. Field personnel determined from state and local sources the acreage of land administered by other federal agencies.

SCS used existing data to measure roads and railroads that connect rural and urban areas to determine the amount of land used for major rural transportation systems. Transportation categories included:

1. Interstate highways
2. Paved primary federal and state highways
3. Other paved roads
4. Gravel roads
5. Dirt roads
6. Railroads

The number of miles of roadway in each transportation category, the average width of the corridor, and the total acreage occupied were recorded.

PSU Data.--Maps were submitted to the Statistical Laboratory showing the location and extent of urban and built-up land of more than 40 acres and the location and extent of irrigated land. The Statistical Laboratory used these maps in selecting the size and location of PSU's and then notified the SCS field offices that were to gather the field data. SCS obtained the following information for each PSU:

o Size.--The actual size of each PSU in acres was recorded. For irregularly shaped PSU's the acreage was determined by dot grid or by planimetering (see glossary) the area on a map or photograph.

o Urban and Built-up Land.--The acreage of urban and built-up land in each PSU was determined. This acreage included contiguous areas of more than 10 acres used for residences, industrial and commercial sites, institutional sites, railroad yards, small parks, cemeteries, airports, and similar urban facilities.

o Small Built-Up Land.--The acreage of small built-up areas was also determined in each PSU. These areas are like "Urban and Built-Up Land" except that they are smaller than 10 acres but larger than 0.25 acre.

o Farmsteads.--The acreage of farmsteads in each PSU was determined. This acreage included land used for dwellings, buildings, barns, pens, corrals, windbreaks, family gardens, and other purposes connected with operating farms or ranches.

o Water Bodies Less Than 40 Acres.--All permanent water bodies of less than 40 acres were identified and their use was recorded. This information was recorded for all water bodies even if only part of their total area was within the PSU. SCS field personnel recorded at least one but no more than three of the following uses for each water body:

1. Irrigation

2. Livestock water

3. Water supply (municipal, industrial, household, firefighting)

4. Recreation, fish, and wildlife

5. Erosion and sediment control

6. Flood prevention and flood control

7. Water quality control (livestock waste lagoons and sewage lagoons)

8. Other (power, navigation, cooling, etc.)

o Perennial Streams Less Than One-Eighth Mile Wide.--SCS also collected data on the width, length, and acreage of the parts of perennial streams less than one-eighth mile wide that were within each PSU. The field personnel determined that the water in each perennial stream was used for at least one but no more than two of the following purposes:

1. Irrigation

2. Livestock water

3. Water supply (municipal, industrial, household, firefighting)

4. Recreation, fish, and wildlife

5. Other (power, navigation, cooling, drainage, etc.)

The most important use was recorded first.

o Perennial Streams More Than One-Eighth Mile Wide.--Field personnel recorded whether the PSU contained part of a perennial stream wider than one-eighth mile.

o Construction.--Data were recorded about any construction activities within the PSU involving an area of more than 1 acre. Construction areas were defined as land areas where man has modified the land surface, that were bare of vegetation at the time of observation, and that were expected to remain without plant cover for more than 30 days.

o Roads.--SCS also recorded any rural road within the PSU. For the purpose of this inventory, roads included farm lanes, logging roads, woods roads, and other private roads as well as paved or gravel public roads. (Roads included in "Urban and Built-Up Land" were not in this category.)

o Active Gullies.--Field personnel recorded the number of active gullies in each PSU. An active gully was defined as an eroding channel through which water flows only during and immediately after heavy rains or during the melting of snow. For the purpose of this inventory, a gully was further defined as a channel 1 foot or more deep.

Data on construction sites, roads, and gullies were recorded as preliminary information for use in a subsequent phase of the NRI concerning roadside, streambank, construction site, and gully erosion.

Sample Point Data.--The PSU data were the main source of information about the total acreage of farmsteads and small urban, built-up, and water areas. SCS obtained more specific information from the point data in the NRI. An SCS representative visited each PSU and made observations at random points in the PSU selected by the Statistical Laboratory. Some information had to be obtained from the owner or operator of a farm. For data points on land that had been in crop production at some time during the previous 4 years, the kinds of crops and residue were determined for each year. This information was used in the wind erosion and universal soil loss equations.

Other information was gathered at each point. For all land areas, this included the soil name and symbol, the land capability class and subclass (see "land capability classes and subclasses" in the glossary), and the soil loss tolerance (see "Universal Soil Loss Equation," below). A determination was made as to whether the point was on prime farmland. For urban areas, SCS gathered information on the density of urban development. For rural lands, the information obtained included the type of irrigation, the kinds of con-

servation practices being applied, the treatment needs, the type of ownership, and data for the universal soil loss and wind erosion equations. For rural noncropland, SCS gathered data on potential cropland, and for water, on the size of the stream or water body.

In addition to the soil and water data, other information was collected at each sample point. This information included the land use and whether or not the point was in a flood prone area or in an area that met the definitions of type 3 to 20 wetlands (Shaw and Fredine, 1956). For urban lands, SCS estimated the amount of impervious cover. For points on irrigated land, the type of irrigation was recorded. Field personnel recorded the type of ownership, the existing conservation practices, and the type of treatment needs. For undeveloped land not in cropland, the potential for conversion to cropland was determined, the major soil and water problems or other problems that might hinder conversion to cropland were noted, and the type of effort necessary for conversion was determined.

Use of Soil Surveys

For the NRI, states had the option of mapping the entire primary sample unit (PSU) in accordance with the standards and procedures of the National Cooperative Soil Survey or of determining the specific soil map unit (see glossary) at individual sample points. This means that uniform soil survey interpretations were made for each sample point. These interpretations provided such information as the K and T values for the universal soil loss equation (see below), the I factor for the wind erosion equation (see below), and the land capability class and subclass. The subclasses define the limitations of the soil, including wetness, erodibility, and such climatic and inherent soil problems as stoniness, droughtiness, and salinity.

Universal Soil Loss Equation

The universal soil loss equation (USLE) is a formula used to predict soil losses caused by water erosion. It was used to estimate sheet and rill erosion for the NRI.

The use of equations to calculate field soil loss began around 1940 in the Corn Belt. A national committee met in Ohio in 1946 to adapt the Corn Belt equation to cropland in other regions. This committee reappraised the Corn Belt factor values and added a rainfall factor. The resulting formula, generally known as the Musgrave Equation, has been widely used for estimating gross erosion from watersheds in flood abatement programs.

The USLE was developed at the National Runoff and Soil Loss Data Center, which was established in 1954 by the Agricultural Research Service (now Science and Education Administration [SEA]) in cooperation with Purdue University. Federal-state cooperative research projects at 49 locations contributed more than 10,000 plot-years (see glossary) of basic runoff and soil loss data to this center for summarization and statistical analyses. After 1960, rainfall simulators operating from Indiana, Georgia, Minnesota, and Nebraska were used on field plots in 16 states to fill some of the gaps in the data needed for factor evaluation.

Analyses of this basic data provided several major improvements for the soil loss equation: (a) a rainfall erosion index evaluated from local rainfall characteristics, (b) a quantitative soil erodibility factor that is evaluated directly from soil properties and is independent of topography and rainfall differences, (c) a method of evaluating cropping and management effects in relation to local climatic conditions, and (d) a method of accounting for effects of interactions among cropping systems, productivity levels, tillage practices, and residue management.

Developments since 1965 have expanded the use of the universal soil loss equation by providing techniques for estimating site values of its factors for additional land uses, climatic conditions, and management practices.

The equation is: A = RKLSCP.

A is the average annual soil loss in tons per acre predicted for a given area.

R is the rainfall erosion factor. Soil is eroded from cultivated land in direct proportion to the product of kinetic energy multiplied by the maximum 30-minute intensity of a rainstorm. This product, called the erosion index, shows the erosion potential of the rainfall within a given period. Annual erosion indexes and monthly rainfall distribution curves have been computed for locations throughout the United States where sheet and rill erosion is a problem. These curves were developed using Weather Bureau and SEA data accumulated over more than 20 years.

K is the soil erodibility factor, which expresses soil loss in tons per acre per unit of rainfall erosion index (R) for a slope of specified dimensions, steepness, and length. K factors vary with soil type, series, and degree of erosion. K values have been determined for all soils on the basis of the soil characteristics that determine erodibility.

L is the length of slope factor. This factor is the ratio of soil loss from a specific length of slope to that from the length specified for the K factor of the equation. Slope length is defined as the distance from the point of origin of overland flow to the point where the slope decreases and deposition begins, or to the point where runoff enters a well defined channel.

S is the steepness of slope factor. It is the ratio of soil loss from the field slope gradient to that from a standard slope under otherwise identical conditions.

C is the cover and management factor. This factor takes into account the combined effect of crops, crop sequence, and various management practices on soil erosion. It is the expected ratio of soil loss from land cropped under specified conditions to soil loss from continuously cultivated fallow land with identical soil, slope, and rainfall conditions. SCS has estimated C factors for rangeland and forest land as well as for cropland.

P is the erosion control practice factor. This factor is the ratio of soil loss under a specified conservation practice to that with uphill and downhill farming operations when other conditions, such as soil, slope, and rainfall, are equal.

Soil Loss Tolerance (T).--In addition to the USLE factors, SCS determined the kind of soil and the average annual soil loss tolerance (T) factor at each random point. This factor is the soil loss in tons per acre per year that can be tolerated indefinitely without interfering with a sustained high level of production. The amount lost through erosion can be no greater than that replaced through soil building processes. T values have been established for all soils. They range from 2 to 5 tons per acre per year.

Use of the USLE in the National Resource Inventories (NRI).--SCS gathered data from each NRI sample point to determine each factor in the USLE. The annual soil loss per acre was computed at each point classified as "all cropland," "cultivated cropland," "forest land," "rangeland," or "pastureland." Computations of sheet and rill erosion did not include points in water, snow and ice fields, farmsteads, other land in farms, quarries and pits, barren lands, or urban lands where C factors were not available and the USLE did not apply.

Wind Erosion Equation

Wind erosion occurs throughout the Great Plains States and in certain parts of other states. SEA developed a formula, the wind erosion equation (WEQ), to predict soil losses caused by wind erosion (Skidmore and Woodruff, 1968). SCS used the wind erosion equation, which combines the primary factors that influence wind erosion, to develop wind erosion estimates for the 10 Great Plains states.

The equation is: $E = f(IKCVL)$.

E is the potential annual soil loss in tons per acre per year.

f equals the function of IKCVL.

I is the soil erodibility factor. It is expressed as the average annual soil loss per acre that would occur from an isolated, level, smooth, unsheltered, wide, and bare field with a noncrusted surface at the location reference of Garden City, Kansas.

K is the soil ridge roughness factor. A field is considered smooth, semi-ridged, or ridged.

C is the climatic factor. This factor is based on the average wind velocity and on the precipitation-evaporation index for that location.

V is the vegetative cover. This value combines the quantity, kind, and orientation of the residue. The V is expressed as residue equivalent to flat, small grain residue.

L is the unsheltered distance across a field along the prevailing wind direction. The unsheltered area of a field begins leeward of a protected area or from a barrier at a distance of 10 times the effective height of the barrier, perpendicular to the prevailing wind direction.

Use of WEQ in the National Resource Inventories (NRI).--For selected points in states where wind erosion is considered a serious problem, SCS tried to

determine the value for each factor in the wind erosion equation and compute the expected soil loss per acre under existing conditions. This attempt was unsuccessful except in the 10 Great Plains states. For the 1980 RCA Appraisal, therefore, SCS confined the use of the wind erosion equation to designated counties in the Great Plains.

Data on Fish and Wildlife Habitat

Wildlife Habitat.--Most data used to evaluate wildlife habitat came from the 1977 National Resource Inventories (NRI) (USDA, 1978b). See page 7-1 for an explanation of this inventory.

For assessing the problems associated with wildlife habitat, SCS evaluated NRI data to determine (1) the vegetative diversity, that is, the combination of land uses, on each primary sample unit, and (2) the quality of the habitat provided by each land use type.

The diversity and quality ratings are displayed in chapter 3, section D, for cropland, forest land, and rangeland, by aggregated subarea (ASA) (see glossary). USDA used the diversity and quality ratings independently to identify potential wildlife habitat problem areas.

Wetlands.--USDA compared wetland inventory data collected in 1954 by the Fish and Wildlife Service to wetland inventory data collected in 1977 by SCS in order to determine the annual rate of wetland loss. See table 3D-1 in chapter 3, section D. USDA estimated the acreage of wetland types 1 and 2 because these two types were not inventoried in 1977.

Fish Habitat.--Descriptions of fish habitat problems were based on water quality and flow requirements for reservoirs and streams. USDA used the Environmental Protection Agency's (EPA) definitions of water quality for the following pollutants: nonpoint source nutrients, pesticides, and sediment (EPA, 1977). The instream flow approximations are from the Second National Water Assessment (USWRC, 1978).

For farm ponds (see chapter 3, section D), USDA used the SCS reporting system. This system records the number of farm ponds and identifies those that are adequately managed for fish.

Water Data

The primary sources for the water data included in the RCA Appraisal are:

The Nation's Water Resources, U.S. Water Resources Council (WRC) 1968.--The First National Water Assessment, prepared by WRC under authority of the Water Resources Planning Act of 1965 (Public Law 89-80), describes the Nation's water and related land resources, their use and management problems, and WRC findings and recommendations. This first assessment was based upon existing data and limited analysis; it relied heavily on the judgment of federal and state water officials. Steps were recommended to improve future assessments.

The Nation's Water Resources 1975-2000, WRC 1978.--The Second National Water Assessment was prepared by WRC and its member agencies under authority of

Public Law 89-80. It presents nationally consistent data on current and projected water use and supply by regions and aggregated subregions (ASR's) and on present and emerging critical (severe) water problems.

WRC initiated the Second National Water Assessment in October 1974. Analysis of the data used 1975 as the base year. WRC and made projections for 1985 and 2000. The United States (including Alaska, Hawaii, and the Caribbean) has 21 water resources regions, which for the purposes of the Second National Water Assessment were divided into 106 aggregated subregions. A subregion consists of one basin or a group of basins for which data could be collected and compiled. WRC compiled comprehensive data and information for each subregion.

This assessment was performed in three major phases: (1) nationwide analysis, (2) specific problem analysis, and (3) national problems analysis.

The nationwide analysis was conducted by WRC member agencies. It reflects their views of existing and future water requirements, the nature of problems, conflicts associated with efforts to meet the requirements, and implications for the future.

The specific problem analysis was conducted on behalf of WRC by a group in each of the 21 water resources regions. Each group was composed of representatives from state and federal agencies. The specific problem analysis viewed resource conditions and problems from a state and regional perspective.

For the national problems analysis, WRC used the results of phases one and two to assess national problems. The report gives an overview of water resource management problems at the national, regional, and subregional levels.

The assessment consists of four volumes (and drafts thereof), statistical appendices, technical memoranda, technical committee reports, nationwide analysis of functional uses and supplies, and contributing agencies' open files.

- Volume 1, December 1978: Summary
  (Highlights water supply, water use, and critical problems.

- Statistical Appendix, Vol. A-1, 1978 Draft: Economics, Social, and Environmental Data
  Lists numerical data by aggregated subareas (ASA's) (see glossary) for 1975 and, in most cases, as projected to 2000. Data include population, employment, and income earnings; land and water areas, cropland harvested, irrigated land, and forest land conversion; erosion estimates, flood damages, recreation requirements, navigation commodities, wilderness areas, stream miles, and streams meeting water quality standards; and heat, biological oxygen demands, and total suspended solids in water.

- Statistical Appendix, Vol. A-2, Parts 1 & 2, 1978 Draft: Water Supply and Use Data

Lists numerical data by aggregated subregions (ASR's) including monthly and annual streamflow analysis; surface storage; ground water storage, withdrawals, and mining; and imports, exports, evaporation, instream flow uses, offstream withdrawals, and consumption.

- Statistical Appendix, Vol. A-3, 1978 Draft: Streamflow Conditions
  Displays selected statistics at gages, annual and monthly streamflows by frequencies, and critical period analyses, by ASR.

- Appendix, Vol. B, 1978 Draft: Methodologies and Assumptions
  Documents how member agencies of the WRC arrived at specific data.

- Part III, 1978 Draft: Functional Water Uses
  Discusses the Agricultural Resource Assessment System (ARAS) in the chapter "Food and Fiber Production and Related Resource Considerations," one of 13 functional use chapters.

- Part IV, 1978 Draft: Water Supply and Water Quality Considerations
  Presents information on water supply, requirements, and balances; pollution and water quality issues; and aspects of water allocation and management.

- Part V, 1978 Draft: Regional Assessment Summaries
  Contains brief statements covering each region or land area, major river systems and the water supply situation, goals and objectives, a synopsis of water-related problems and issues, and general conclusions and recommendations.

- Estimated Flood Damages, Appendix B, January 1977: Nationwide Analysis Report
  Contains the WRC Technical Committee report on nationwide flood damages for 1975, 1985, and 2000. It shows the effects of flooding by upstream and downstream areas, by monetary damages to urban, agricultural, and other properties, by areas inundated, by communities with flooding problems, and by severity based on selected criteria. It evaluates this information and discusses its implications.

- Preliminary Upstream Flooding, USDA open file, 1975
  Contains the USDA inventory and analysis of upstream flooding estimates that were submitted to WRC. The file outlines USDA's methodology, assumptions, findings, and analysis.

- Livestock Water Use, Appendix C-1, July 1975: Nationwide Analysis Report
  Contains USDA estimates and projections of livestock water use. The requirements (use) are based on (1) drinking water and other water use rates, and (2) livestock production. Severe livestock water problems are discussed.

- Domestic Water Use from Non-Central Systems, Appendix C-2, July 1975: Nationwide Analysis Report
  Contains USDA determinations of 1975 and projected water requirements for self-supplied systems, based on per capita consumption and the

number of noncentral system users. A companion appendix (C-3) provides data on domestic water use from central systems.

o Outdoor Recreation Requirements and Related Problem Issues, Appendix D, May 1975 Nationwide Analysis Report
Uses estimates and projections by USDI's Bureau of Outdoor Recreation (now the Heritage Conservation and Recreation Service) of water and related land areas needed for outdoor recreation. It outlines nine problem issues and lists the attributes and concerns for specific areas (stream reach miles or lake and adjacent areas) that are of critical environmental concern.

1972 OBERS Projections: Series C and E Population, WRC 1974.--OBERS series are projections of economic activity for the Nation and states, and for economic, statistical, and hydrologic areas. They include projections of population, personal income, employment, and earnings by persons and by industry. Agricultural projections include commodity production and value and the use of land for farming. (See "Demand for Agricultural Products" in chapter 2 for an explanation of the OBERS series.)

Both OBERS Series C and E were published for 1972. Series C assumes birth rates higher than experienced in the late 1960's and early 1970's. Series E assumes a birth rate that will eventually result in no further population growth except through immigration. The Series E assumption results in a population of 264,430,000 in the year 2000. Series E is the most widely used in population projections.

o 1972 OBERS Projections Supplement: Series E' (Prime), May 1975, WRC
The agricultural portion of the Series E was revised in 1975 to reflect changes in domestic consumption patterns and increased exports. Exports were assumed to be higher than in the 1960's but below the high levels of the early 1970's. These revised projections, referred to as E Prime (E'), are the most widely accepted estimates used in resource planning.

Agricultural Resource Assessment System (ARAS), USDA open file, 1977.--USDA analyzed possible future use of water for agricultural purposes with the help of an interagency technical advisory committee. To perform the statistical work, USDA combined a national agricultural simulation model developed by ESCS and a linear programming model developed by Iowa State University (see "The 1980 RCA Yield/Soil Loss Simulator" and "The CARD-USDA National Agricultural Linear Programming Model" in section B). Information is presented on the quantities of water potentially available and the estimated use of water by agriculture, and on the potential economic and environmental effects of alternative policies. Data on acreages, yields, demands, and other factors are projected under an array of possible circumstances.

Crop Consumptive Irrigation Requirements (CIR) and Irrigation Efficiency Coefficients for the United States, SCS-USDA, June 1976.--Monthly CIR, conveyance and onfarm efficiencies, and incidental losses are listed by crop by subareas within each state for average dry-year conditions. The 3,900 entries are nationally consistent; most were computed using the Modified Blaney-Criddle Method outlined in Soil Conservation Service Technical Report 21. The 23-page narrative preceding these tabulations presents a national

overview of irrigation water requirements and efficiencies, and it presents possibilities for future efficiencies.

Irrigation Water Use and Management, An Interagency Report, USDI, USDA, and EPA, June 1979.--Federal agencies jointly produced this 133 page report in response to issues raised by the Comptroller General of the United States on the efficiency of onfarm and irrigation conveyance systems. The states were represented by the Governor of Utah in his role as Chairman of the Subcommittee on Water Management, Natural Resources and Environmental Management Committee of the National Governor's Association.

Preparation of this report included--

(1) compilation of relevant data and information on the development of irrigation in the United States.

(2) review of the legal and institutional aspects of water use.

(3) review of current state, local, and federal programs.

(4) assessment of the causes and results of inefficiencies.

(5) analysis of the measures, costs, and effects of improving irrigation water use and management in the 17 western states.

(6) presentation of the special problems related to irrigation in humid areas.

(7) presentation of a statement on approaches to implementing water conservation programs in irrigated agriculture.

Major features of the report are a series of conclusions, 16 recommendations for action, and the views of the states.

The report documents the data used in preparing the analysis. It includes as much information from the participating state and federal agencies as possible. No new data were collected in the 17 western states, but some data were updated and aggregated for the study. The Soil Conservation Service and the Extension Service, however, gathered additional information in the 31 eastern states. This information included the amount of irrigated land, the water supply for irrigation, the types of irrigation systems, and the average depth of irrigation water, by state.

The report presents data and information by irrigation characterization areas and presents case studies to emphasize and highlight selected situations. The report also presents irrigation water budgets with and without an accelerated irrigation water conservation program for the 17 western states. The accelerated program is based on field technicians' estimates of the measures that most farmers would undertake if adequate incentives were available. The level of improvement is consistent with that already achieved by the more progressive irrigation farmers, who use current private and public technical and financial sources of assistance.

Weather and Water Allocation Study, USDA, Draft, November 1978.--This report assesses climate and weather conditions in the United States and the possible

impacts of changes in them on the Nation's economy and future food and feed availability and prices. It also reviews water allocation policies and considers strategies and techniques for dealing with water shortages.

Summary Appraisals of the Nation's Ground Water Resources (by Water Resource Region), USGS Professional Paper(s) 813.--This series of papers presents information on the distribution, availability, and quality of ground water and its importance in regional water supplies. It discusses alternatives for managing ground water in water resource planning and development.

Upstream Flood Damages, June 1979.--This report, prepared for SCS by Charles W. Williams, Inc., provides an assessment of rural flooding damage and of costs and benefits of programs to reduce damages.

National Water Data Exchange (NAWDEX) Program.--NAWDEX is a national confederation of water-oriented organizations working together to improve access to water data. Federal and Nonfederal Interagency Advisory Committees on Water Data for Public Use, working under the auspices of the U.S. Geological Survey (USGS), acquire, store, and disseminate water data as prescribed by Circular A-67 (Office of Management and Budget, 1964). NAWDEX is designed to assist users of water data in identifying, locating, and acquiring needed data. NAWDEX indexes data held by others and provides a central source of available information on water.

NAWDEX has direct access to several large water-data bases:

1. The Water Data Storage and Retrieval System (WATSTORE) is a USGS file containing data on streamflow, water quality, sediment discharge, and ground water levels.

2. The Storage and Retrieval (STORET) system of EPA contains observations on the quality of both surface and ground water.

3. The Environmental Data Service (EDS) of the National Oceanic and Atmospheric Administration (NOAA) in the U.S. Department of Commerce provides bibliographic and data services through its Oceanic and Atmospheric Scientific Information System (OASIS) and environmental references through its Environmental Data Index (ENDIX).

4. The Water Resources Scientific Information Center (WRSIC) of the U.S. Department of the Interior's Office of Water Research and Technology has computerized abstracts on water resource subjects.

5. The Texas Natural Resources Information System (TNRIS), the Iowa Water Resources Data System (IWARDS), and the Regional Environmental Assessment Program (REAP) are examples of accessible data sources maintained by state and regional organizations.

NAWDEX refers to a number of storage and retrieval systems. These systems include: National Stream Quality Accounting Network (NASQAN)--445 of 525 planned stations measure the quality of America's streams; Water Use Information System (WUIS)--generating plant information, cooling, and operation assist energy planners; Snow Telemetry (SNOTEL)--remote signals relay snow and rainfall data for forecasting water supplies.

Literature Search

The 1977 National Resource Inventories (NRI) contained the following kinds of data for nonfederal lands: land use, conservation treatment needs, soil capabilities, prime farmlands, potential croplands, sheet and rill erosion, wind erosion, irrigation, water bodies and streams, use of small water areas, flood prone areas, and wetlands. The RCA Appraisal used NRI data directly as reported in some instances; in others, it further analyzed and interpreted these data to show specific conditions or problems. The RCA Appraisal also used other national inventories:

1. The Soil Conservation Service's 1963 Range Condition Survey on Nonfederal Lands, by B.W. Allred (SCS Special Survey)

2. The Soil Conservation Service's 1977 Range Condition Survey on Nonfederal Lands (SCS Special Survey)

3. The Soil Conservation Service's 1973 Brush Inventory for Nonfederal Lands in the United States, by Lorenze Bredemeir (SCS Special Survey)

4. The Soil Conservation Service's 1958 Conservation Needs Inventory

5. The Soil Conservation Service's 1967 Conservation Needs Inventory

6. The Soil Conservation Service's Status of Land Disturbed by Surface Mining in the United States: Basic Statistics by State and County as of July 1, 1977

7. The Environmental Protection Agency's 1975 National Water Quality Inventory

8. The Environmental Protection Agency's 1978 National Water Quality Inventory

9. The U.S. Water Resources Council's 1968 First National Water Assessment

10. The U.S. Water Resources Council's 1978 Second National Water Assessment

11. The National Association of Conservation Districts' 1977 Inventory of Private Recreation Facilities

12. The Fish and Wildlife Service's 1973 National Survey of Hunting, Fishing, and Wildlife-Associated Recreation

13. The Forest Service's 1977 Forest Statistics of the United States

The data in these inventories were compared to and supported by information taken from other special reports, research papers, publications, and other sources. Other technical documents providing both data and information were obtained through searches of eight computer data bases.

A task group of resource specialists and researchers employed by SCS, the National Agricultural Library (NAL), and the Library of Congress searched these data bases. The group developed search strategies for various resource concerns according to NAL Technical Information Search procedures. They surveyed more than 1.5 million technical publications and studies, from which they selected a bibliography of more than 6,000 sources containing data or information on renewable natural resources, their management, related problems, and use. They reviewed about 400 of the most specific and relevant papers in detail, summarized them, and used them as support information for the 1980 RCA Appraisal. About 200 of these items are cited in Part I, which reviews the status, condition, and trend of soil and water resources.

Section B-Modeling

The CARD-USDA National Agricultural Linear Programming Model

The ability to predict the response of the Nation's agriculture to changes in agricultural policy is essential to the formulation of that policy. A linear programming model of the Nation's agricultural sector is helping the U.S. Department of Agriculture predict the effects of proposed policy changes.

The Center for Agricultural and Rural Development (CARD), at Iowa State University, and the United States Department of Agriculture developed the National Agricultural Linear Programming Model. This model processes selected data about the agricultural economy and produces tables that can be summarized or aggregated for policymakers. It uses the following variables: (1) the cost of producing agricultural goods, (2) the activities involved in producing, processing, and transporting these goods, (3) the demand for the goods, and (4) the resources available to produce the goods. The markets in the agricultural economic system are considered in the formula. Controls over resource use or governmental constraints on the use or production of commodities are also considered in the formula.

Policymakers can use the linear programming model to evaluate alternative policies. They can add new markets to the model if a new policy requires them. They can change the model to reflect changes in demand, availability of resources, costs, or the level of activity required for crop production.

Some of the effects of policy alternatives that the linear programming model can evaluate are listed below.

- Regional availability of resources.--The model can evaluate the effects on crop production of policy changes affecting land use, water rights, or resources.
- Soil loss limitations.--The model can predict the soil loss that would occur on marginal cropland if that land were brought into crop production.
- Fertilizer use and prices.--The model can evaluate the effects of higher fertilizer prices on fertilizer use and, by extension, yields and crop rotations.
- Demand.--The model can predict how changes in patterns of consumption would affect the production of agricultural products.
- Exports.--The model can predict how changes in foreign demand for agricultural products would affect agricultural production.
- Farming techniques.--The model can evaluate the effects of irrigation, crop varieties, technology, and tillage practices on crop production.
- Changes in prices of agricultural products.--The model can analyze changes in the amount or location of agricultural production resulting from changes in the prices of agricultural products.
- Environmental policies.--The model can evaluate the effects of environmental policies that constrain use of erodible land or that require production of certain agricultural products.

Because of the wide variations in climate, soil, and farm structure in American agriculture, the model must allow for possible regional adjustments. These adjustments reflect markets and activities in which demands for prod-

ucts or constraints on the availability of resources are determined within a single region. The model uses transportation networks to balance demand and resource interactions among regions.

The CARD-USDA National Agricultural Linear Programming Model, therefore, is an interregional model. It contains data about the resources of each region and about the production techniques used there. It imposes constraints on the availability and use of resources and on commodity production, processing, and transportation.

Limitations of the Linear Programming Model.--The National Agricultural Linear Programming Model is useful and versatile in evaluating alternative agricultural policies. It assumes that each unit of input to production results in the same amount of output. Further, it assumes that there are no differences in the efficiency of operations of different size. These characteristics provide a normative model that predicts the location of production, the amount of production, and the cost of production. This type of model, however, does not provide much direct information on how a program could be developed to carry out specific policy alternatives. A model that would provide this information could be formulated, but it would be difficult and expensive to develop. The National Agricultural Linear Programming Model, therefore, is useful in impact analysis, but it is less reliable for transformation analysis.

The model can provide a large amount of information about the direction and possible effects of any policy. As in any modeling effort, however, interpretations must be strictly in line with the capabilities of the model; no model is more accurate than the data used as input. The production, processing, and transportation activites must be accurately recorded and entered. Failure to include the appropriate variables could restrict the system as it searches for the optimum solution. If the proper variables have not been provided, the model may not provide accurate simulations.

Contact Ernest V. Todd, RCA Manager, Room 5123, P.O. Box 2890, Washington, D.C. 20013, for a more detailed description of the CARD-USDA National Agricultural Linear Programming Model.

The Farm Enterprise Data System

The Agriculture and Consumer Protection Act of 1973 (Public Law 93-86) directs the Secretary of Agriculture to annually estimate the costs of producing certain major commodities under the various production practices and to establish a current national weighted average cost of production. Consequently, the U.S. Department of Agriculture conducts comprehensive research on costs of production through the Commodity Economics Division (CED) of the Economics, Statistics, and Cooperatives Service (ESCS).

Data for the costs of producing crops come from a variety of sources. The primary source is a 1974 survey of more than 4,000 producers. Many other units in ESCS and in other USDA agencies contribute data and information. Land-grant universities help process the data and review enterprise budgets. The CED commodity program areas provide the final estimates for their respective commodities. The major commodities are cotton, corn, grain sorghum, barley, wheat, soybeans, peanuts, flaxseed, oats, and rice.

The Farm Enterprise Data System (FEDS) processes and evaluates these data. The FEDS procedure is designed primarily to provide annual updates of cost estimates between surveys and to provide projections of costs for the upcoming crop year. The CARD-USDA linear programming model uses the FEDS budgets to make cost estimates of production.

Applied Conservation Effects System

In 1978, the Soil Conservation Service (SCS) developed a system to determine the effectiveness of soil and water conservation measures installed with the assistance of the Conservation Operations Program. SCS designed the Applied Conservation Effects System (ACES) to assess the effects of conservation management and practices on erosion rates, long term soil productivity, energy use, water use, and volume of surface runoff. ACES also evaluates the investment for and long term economic effects of conservation management. SCS established certain data files within the ACES computer system to store more field data that could be used in calculating the effects of conservation management. In its calculations, the ACES computer system uses a statistically reliable sample of major land resource areas (MLRA's) within and among states. Because of the varied demands on SCS field personnel, ACES is designed to operate effectively with only the most essential field input.

Major land resource areas are characterized by particular patterns of soil (including slope and erosion), climate, water resources, land use, and type of farming (Austin, 1972). MLRA's for the 48 conterminous states were originally mapped and described in 1965. They were slightly revised in 1972. A complete revision now being published includes Alaska and Hawaii (see figs. 7B-1 and 7B-2). However, this revision was not available in time to be incorporated into the ACES calculations. For ACES calculations, the original MLRA boundaries were adjusted to coincide with county boundaries (fig. 7B-3).

The ACES model also uses the Water Resources Council's (WRC) aggregated subareas (ASA's) (see glossary) (fig. 7B-4). WRC recognizes more than 200 hydrologic subregions in the Nation. The subregion boundaries have also been adjusted to coincide with county boundaries, and these adjusted subregions are called hydrologic subareas. The hydrologic subareas have been aggregated into 106 ASA's for computing purposes.

In October 1978, SCS requested that state office specialists furnish certain data on selected MLRA's in their states (see table 7B-1). It requested data from about 1,000 counties nationwide. Because data from the field were to be expanded and analyzed according to capability class and subclass (see "land capability classes and subclasses" in the glossary) or other classification systems, for example, range productivity groups, SCS requested data from a representative soil series for each class-subclass combination in the MLRA.

The raw data were punched onto computer cards and loaded into "online" data files for the ACES computer program. The following paragraphs describe the resource data sets.

<u>Data Set 1</u>.--This data set contains the names of representative soil series and pertinent data for each, including the erodibility factor for the surface layer (see "Universal Soil Loss Equation" in Section A), available water capacity in inches of water per inch of soil, soil loss tolerance value (see

Figure 7B-1.--Major land resource areas in the conterminous United States. Above is a map showing the location of these areas and below is a legend to the map. Letters indicate land resource regions; numbers indicate major land resource areas. Source: Agric. Handb. No. 296, revision in press.

A Northwestern Forest, Forage, and Specialty Crop Region

1 Northern Pacific Coast Range, Foothills, and Valleys
2 Willamette and Puget Sound Valleys
3 Olympic and Cascade Mountains, Western Slope
4 California Coastal Redwood Belt
5 Siskiyou-Trinity Area

B Northwestern Wheat and Range Region

6 Cascade Mountains, Eastern Slope
7 Columbia Basin
8 Columbia Plateau
9 Palouse and Nez Perce Prairies
10 Upper Snake River Lava Plains and Hills
11 Snake River Plains
12 Lost River Valleys and Mountains
13 Eastern Idaho Plateaus

C California Subtropical Fruit, Truck, and Specialty Crop Region

14 Central California Coastal Valleys
15 Central California Coast Range
16 California Delta
17 Sacramento and San Joaquin Valleys
18 Sierra Nevada Foothills
19 Southern California Coastal Plain
20 Southern California Mountains

D Western Range and Irrigated Region

21 Klamath and Shasta Valleys and Basins
22 Sierra Nevada Range
23 Malheur High Plateau
24 Humboldt Area
25 Owyhee High Plateau
26 Carson Basin and Mountains
27 Fallon-Lovelock Area
28A Great Salt Lake Area
28B Central Nevada Basin and Range
29 Southern Nevada Basin and Range
30 Sonoran Basin and Range
31 Imperial Valley
32 Northern Intermountain Desertic Basins
33 Semiarid Rocky Mountains
34 Central Desertic Basins, Mountains, and Plateaus
35 Colorado and Green River Plateaus
36 New Mexico and Arizona Plateaus and Mesas
37 San Juan River Valley Mesas and Plateaus
39 Arizona and New Mexico Mountains
40 Central Arizona Basin and Range
41 Southeastern Arizona Basin and Range
42 Southern Desertic Basins, Plains, and Mountains
48A (See E)

E Rocky Mountain Range and Forest Region

43 Northern Rocky Mountains
44 Northern Rocky Mountain Valleys
46 Northern Rocky Mountain Foothills
47 Wasatch and Uinta Mountains
48A Southern Rocky Mountains
48B Southern Rocky Mountain Parks
49 Southern Rocky Mountain Foothills
51 High Intermountain Valleys

F Northern Great Plains Spring Wheat Region

52 Brown Glaciated Plain
53A Northern Dark Brown Glaciated Plains
53B Central Dark Brown Glaciated Plains
53C Southern Dark Brown Glaciated Plains
54 Rolling Soft Shale Plain
55A Northern Black Glaciated Plains
55B Central Black Glaciated Plains
55C Southern Black Glaciated Plains
56 Red River Valley of the North
57 (See K)
58A (See G)

G Western Great Plains Range and Irrigated Region

58A Northern Rolling High Plains, Northern Part
58B Northern Rolling High Plains, Southern Part
58C Northern Rolling High Plains, Northeastern Part
58D Northern Rolling High Plains, Eastern Part
60A Pierre Shale Plains and Badlands
60B Pierre Shale Plains, Northern Part
61 Black Hills Footslopes
62 Black Hills
63A Northern Rolling Pierre Shale Plains
63B Southern Rolling Pierre Shale Plains
64 Mixed Sandy and Silty Tableland
65 Nebraska Sand Hills
66 Dakota-Nebraska Eroded Tableland
67 Central High Plains
69 Upper Arkansas Valley Rolling Plains
70 Pecos-Canadian Plains and Valleys

H Central Great Plains Winter Wheat and Range Region

71 Central Nebraska Loess Hills
72 Central High Tableland
73 Rolling Plains and Breaks
74 Central Kansas Sandstone Hills
75 Central Loess Plains
76 Bluestem Hills
77 Southern High Plains
78 Central Rolling Red Plains
79 Great Bend Sand Plains
80A Central Rolling Red Prairies
80B Texas North Central Prairies
81 (See I)

I Southwest Plateaus and Plains Range and Cotton Region

81 Edwards Plateau
82 Texas Central Basin
83A Northern Rio Grande Plain
83B Western Rio Grande Plain
83C Central Rio Grande Plain
83D Lower Rio Grande Valley

J Southwestern Prairies Cotton and Forage Region

80A (See H)
84A Cross Timbers
84B West Cross Timbers
84C East Cross Timbers
85 Grand Prairie
86 Texas Blackland Prairie
87 Texas Claypan Area

K Northern Lake States Forest and Forage Region

57 Northern Minnesota Gray Drift
88 Northern Minnesota Glacial Lake Basins
90 Central Wisconsin and Minnesota Thin Loess and Till
91 Wisconsin and Minnesota Sandy Outwash
92 Superior Lake Plain
93 Superior Stony and Rocky Loamy Plains and Hills
94A Northern Michigan and Wisconsin Sandy Drift
94B Michigan Eastern Upper Peninsula Sandy Drift

L Lake States Fruit, Truck, and Dairy Region

95A Northeastern Wisconsin Drift Plain
95B Southern Wisconsin and Northern Illinois Drift Plain
96 Western Michigan and Northeastern Wisconsin Fruit Belt
97 Southwestern Michigan Fruit and Truck Belt
98 Southern Michigan and Northern Indiana Drift Plain
99 Erie-Huron Lake Plain
100 Erie Fruit and Truck Area
101 Ontario Plain and Finger Lakes Region

M Central Feed Grains and Livestock Region

102A Rolling Till Prairie
102B Loess Uplands and Till Plains
103 Central Iowa and Minnesota Till Prairies
104 Eastern Iowa and Minnesota Till Prairies
105 Northern Mississippi Valley Loess Hills
106 Nebraska and Kansas Loess-Drift Hills
107 Iowa and Missouri Deep Loess Hills
108 Illinois and Iowa Deep Loess and Drift
109 Iowa and Missouri Heavy Till Plain
110 Northern Illinois and Indiana Heavy Till Plain
111 Indiana and Ohio Till Plain
112 Cherokee Prairies
113 Central Claypan Areas
114 Southern Illinois and Indiana Thin Loess and Till Plain
115 Central Mississippi Valley Wooded Slopes

N East and Central Farming and Forest Region

116A Ozark Highland
116B Ozark Border
117 Boston Mountains
118 Arkansas Valley and Ridges
119 Ouachita Mountains
120 Kentucky and Indiana Sandstone and Shale Hills and Valleys
121 Kentucky Bluegrass
122 Highland Rim and Pennyroyal
123 Nashville Basin
124 Western Allegheny Plateau
125 Cumberland Plateau and Mountains
126 Central Allegheny Plateau
127 Eastern Allegheny Plateau and Mountains
128 Southern Applachian Ridges and Valleys
129 Sand Mountain
130 Blue Ridge

O Mississippi Delta Cotton and Feed Grains Region

131 Southern Mississippi Valley Alluvium
134 (See P)

P South Atlantic and Gulf Slope Cash Crops, Forest, and Livestock Region

112 (See M)
133A Southern Coastal Plain
133B Western Coastal Plain
134 Southern Mississippi Valley Silty Uplands
135 Alabama, Mississippi, and Arkansas Blackland Prairie
136 Southern Piedmont
137 Carolina and Georgia Sand Hills
138 North Central Florida Ridge

R Northeastern Forage and Forest Region

139 Eastern Ohio Till Plain
140 Glaciated Allegheny Plateau and Catskill Mountains
141 Tughill Plateau
142 St. Lawrence-Champlain Plain
143 Northeastern Mountains
144A New England and Eastern New York Upland, Southern Part
144B New England and Eastern New York Upland, Northern Part
145 Connecticut Valley
146 Aroostook Area

S Northern Atlantic Slope Diversified Farming Region

147 Northern Appalachian Ridges and Valleys
148 Northern Piedmont
149A Northern Coastal Plain
149B Long Island-Cape Cod Coastal Lowland

T Atlantic and Gulf Coast Lowland Forest and Crop Region

150A Gulf Coast Prairies
150B Gulf Coast Saline Prairies
151 Gulf Coast Marsh
152A Eastern Gulf Coast Flatwoods
152B Western Gulf Coast Flatwoods
153A Atlantic Coast Flatwoods
153B Tidewater Area
153C Mid-Atlantic Coastal Plain

U Florida Subtropical Fruit, Truck Crop, and Range Region

154 South-Central Florida Ridge
155 Southern Florida Flatwoods
156A Florida Everglades and Associated Areas
156B Southern Florida Lowlands

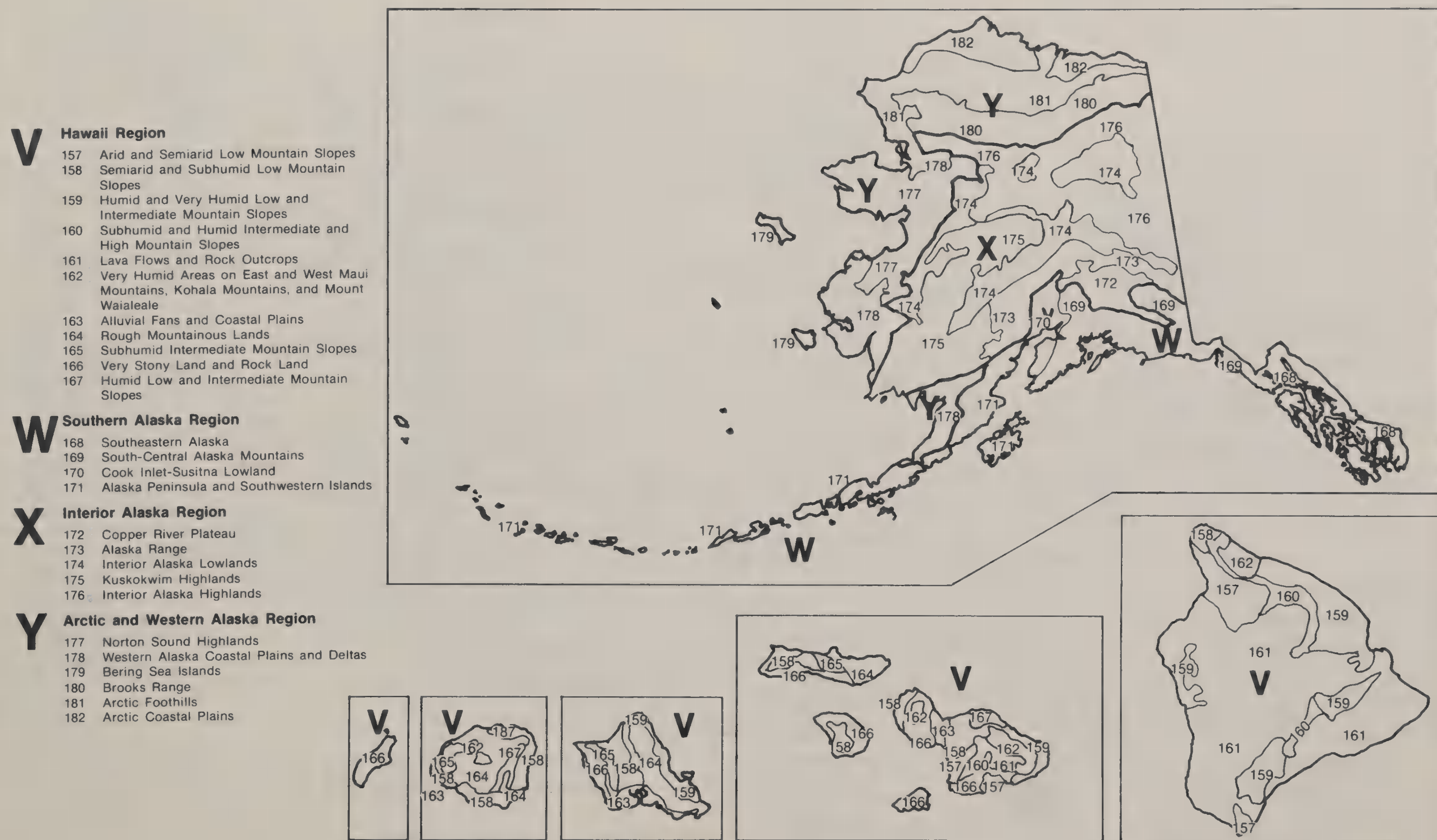


Figure 7B-2.--Major land resource areas in Alaska and Hawaii. Source: Agric. Handb. No. 296, revision in press.

Figure 7B-3.--Major land resource areas adjusted to county boundaries.

Figure 7B-4.--Aggregated subareas. Source: U.S. Water Resources Council.

Table 7B-1.--Major land resource areas included in the Applied Conservation Effects System, by state

State	Major land resource areas
Alabama	125, 128, 129, 135, 136
Alaska	158
Arizona	30, 35, 36, 39, 40, 41
Arkansas	116, 117, 118, 119, 131, 132, 133, 134
California	5, 14, 15, 17, 19, 20, 21, 22, 29, 30, 31
Colorado	45, 48, 51, 67, 69, 72
Connecticut	144, 145
Delaware	149, 153
Florida	133, 138, 152, 153, 154, 155, 156
Georgia	128, 130, 133, 136, 137, 153
Hawaii	As appropriate
Idaho	9, 10, 12, 13, 25, 28, 43, 44, 47
Illinois	95, 105, 108, 110, 113, 114, 115
Indiana	98, 110, 111, 114, 115, 120, 121, 122
Iowa	102, 103, 104, 105, 107, 108, 109
Kansas	72, 73, 74, 75, 76, 77, 78, 79, 80, 106, 107, 112
Kentucky	120, 121, 122, 125, 133, 134
Louisiana	131, 133, 134, 150, 151
Maine	143, 144, 146
Maryland	127, 147, 148, 149, 153
Massachusetts	144, 145, 149
Michigan	92, 93, 94, 95, 97, 98, 99, 111
Minnesota	56, 57, 88, 90, 102, 103, 104, 105
Mississippi	131, 133, 134, 135
Missouri	107, 109, 112, 113, 115, 116, 131
Montana	43, 46, 52, 53, 58, 59
Nebraska	64, 65, 66, 67, 71, 72, 73, 75, 102, 106
Nevada	23, 25, 26, 27, 28, 29, 30
New Hamsphire	143, 144
New Jersey	144, 147, 148, 149
New Mexico	36, 37, 39, 42, 48, 51, 70, 71
New York	101, 140, 142, 143, 144, 149
North Carolina	130, 133, 136, 137, 153
North Dakota	53, 54, 55, 56, 58
Ohio	99, 100, 111, 114, 124, 126, 139
Oklahoma	76, 77, 78, 80, 84, 85, 112, 116, 117, 118, 119
Oregon	1, 2, 6, 8, 9, 10, 23, 43
Pennsylvania	126, 127, 140, 147, 148
Puerto Rico	As appropriate
Rhode Island	144
South Carolina	133, 136, 137, 153
South Dakota	53, 54, 55, 58, 60, 61, 62, 63, 64, 66, 102
Tennessee	122, 123, 125, 128, 130, 131, 133, 134
Texas	42, 77, 78, 80, 81, 82, 83, 84, 85, 86, 87, 133, 150
Utah	28, 34, 35, 47

Table 7B-1.--Major land resource areas included in the Applied Conservation Effects System, by state--Continued

State	Major land resource areas
Vermont--------------	142, 143, 144
Virginia-------------	125, 128, 130, 133, 136, 147, 148, 149, 153
Washington-----------	1, 2, 3, 6, 7, 8, 9, 43
West Virginia--------	125, 126, 127, 128, 147
Wisconsin------------	90, 91, 93, 95, 105, 110
Wyoming--------------	34, 43, 58, 61, 67

"Universal Soil Loss Equation"), wind erosion group, and hydrologic group. In order to provide approximate fetch values for the wind erosion equation (see "Wind Erosion Equation" in section A), the states provided a mean field width for all soil capability class-subclass combinations where wind erosion was a problem.

Data Set 2.--This data set contains production index values for each of five levels of pasture and hayland management. Levels range from improper use and management to proper use and management. Data are for the part of each state within an MLRA.

Data Set 3.--For the part of a state within an MLRA, state specialists recorded the major crop rotations used in the 5 years when erosion was most severe in that region. For each rotation, they listed associated C factor values (see "Universal Soil Loss Equation," section A), for three levels of crop residue use. C factors were listed for both dryfarmed and irrigated cropping systems.

Data Set 4.--This data set contains the additional information needed to calculate soil loss as a result of wind erosion on dryfarmed and irrigated cropland in that part of a state within an MLRA. State offices supplied several types of information:

1. Mean soil ridge height and spacing in inches

2. Mean amount of crop residue remaining on the soil surface, in pounds per acre

3. Mean amount of crop residue equivalent to pounds of flat small grain per acre

Data Set 5.--Calculating the increase in irrigation efficiency provided by water conservation practices required data on "prior to" and "follow up" levels of efficiency. Data set 5 contains data on the level of efficiency of onfarm mainline conveyances, field distribution systems, and irrigation water application using surface, sprinkler, and trickle systems. Data on the level of efficiency were recorded as percentages of the potential efficiency.

Data Set 6.--SCS requested that state range conservationists group range sites into four productivity groups for the part of a state within an MLRA. Because these productivity groups are consistent with the systems used by the Forest Service and the Bureau of Land Management, the ACES range data are directly comparable to and compatible with other surveys and evaluations.

Data Set 7.--Data set 7 contains more data for evaluating rangeland. SCS assembled the following data for each range productivity group within an MLRA:

1. Mean steepness of slope (percent)

2. Representative hydrologic soil group

3. Representative K factor (see "Universal Soil Loss Equation," section A).

4. Mean pounds per acre of available forage, by range condition class in each productivity group

Data Set 8.--The evaluation of woodland required information on C factor values for each of four ground cover classes within an MLRA. In addition, field offices ranked and assigned woodland suitability groups to one of five annual production categories. For each annual production category, the field offices provided the most representative soil series and hydrologic soil group. Using these data and data from specific woodland sites, ACES can evaluate how woodland practices affect production and runoff.

Data Set 9.--In order to evaluate changes in runoff, ACES required rainfall data. SCS selected the 2-year, 24-hour probability storm as the benchmark for evaluating runoff. Field offices noted the inches of rainfall for the 2-year, 24-hour storm for the part of each state within an MLRA.

- Wind Erosion C Value Maps.--SCS requested that each state in which wind erosion was a problem supply a copy of the C value map from their Technical Guide. The values on the maps were then recorded for use in ACES wind erosion computations.

The RFF Model for RCA

Resources for the Future (RFF), supported by a grant from the National Science Foundation, has developed a model that for the first time links pollution-generating activities in each of the Nation's counties to a detailed network of 304 rivers, 175 lakes and reservoirs, and 37 bays. Through simple mathematical transport relationships, this model can relate water quality at one location to pollutants that may originate several hundred miles upstream. It can also predict the ability of lakes and reservoirs to trap and otherwise eliminate pollutants.

The network includes 1,306 nodal points (points at which estimates of pollution levels are made) on rivers, reservoirs, lakes, and bays. Depending on drainage patterns, each of the Nation's 3,209 counties is assigned to at least one of these nodal points. Industrial, municipal, agricultural, and other nonpoint pollution sources (see glossary) are grouped by county. The model estimates the amount of pollutants discharged by these sources, how this amount is affected by policy, and how much the pollutants affect water quality. By adopting standard data classification schemes, the model can use industrial, population, agricultural, pollution, and hydrologic data files maintained by various federal agencies.

The model is part of a larger evaluation process that involves three major steps: determining how policies can affect residual discharges from both point and nonpoint sources, allocating these discharges to counties, and inserting the pollutants into the water network model to compute the resulting ambient concentrations.

Water Network Design.--Water bodies in the network were ranked according to (1) their size, (2) the amount of pollutants they receive, and (3) the size of their drainage area. For example, RFF tried to include all rivers with average flows exceeding 1,000 cubic feet per second (cfs) at their mouths. However, because they did not receive large amounts of pollutants and runoff,

seven rivers in the Northwest were excluded even though their average flows exceeded 4,000 cfs.

On the other hand, some relatively small rivers--such as the Charles in Massachusetts and the Cuyahoga in Ohio--were included because they received pollutants from major urban areas. A number of very small rivers in arid western areas were included because they received runoff from two or more counties.

Bays, lakes, segments of ocean shorelines, and reservoirs were included if they met the three criteria listed above. Many reservoirs that did not meet the criteria were also included if they interrupted the flow of a river in the network.

Many short tributaries and streams were excluded from the network even though they received pollutants. The model assumes that travel time along these short tributaries to the main river is negligible and that their pollutants arrive intact.

o Nodal points.--RFF segmented the water bodies selected for the network in order to locate the nodal points. Nodal points on rivers are near a major population center, where a major tributary enters the network, or at the beginning of an estuary, the entrance to a reservoir, or the river's mouth.

Additional nodal points were established if the distance between the points selected according to these criteria was very large and if the river had passed through four or more counties.

In all, RFF established 1,051 nodal points on rivers and 249 along bays, lakes, and ocean shorelines. The average distance between nodal points is 66 miles. Because the network's average river is 165 miles long, there are about 3.5 nodal points per river. A major river, such as the Mississippi, obviously has many more.

Where possible, in order to simplify data development, nodal points were colocated with United States Geological Survey (USGS) long term streamflow measuring stations. Unfortunately, about 40 percent of the nodal points were not colocated.

Each county in the United States (except for 13 completely arid counties) is assigned to at least one nodal point. Where the county's drainage went into more than one water body in the network, the county was assigned to more than one nodal point. The assignment was based primarily on Soil Conservation Service runoff maps. In some places, however, municipal pollutants are channeled into water bodies where they would not go if natural drainage patterns were followed. Where such situations existed, the runoff maps were ignored. For example, the natural direction of flow of the Chicago River has been reversed. Therefore, the model reflects the fact that the Chicago River rather than Lake Michigan receives point source pollutants.

Although the resulting network is quite large, it is not totally connected. There are 44 independent subnetworks. River-lake-reservoir-bay linkages in any given subnetwork can be quite complex. The Mississippi subnetwork, for example, contains 124 rivers and 78 lakes and reservoirs.

o Sediment delivery ratios.--The RFF model uses sediment delivery ratios to estimate the percentage of gross soil erosion that reaches waterways. Iowa State University developed the sediment delivery ratios as part of their National Model of Sediment and Water Quality. Wade and Heady (1976) give complete details on the development of these ratios.

The sediment delivery ratio is the ratio of observed sediment in the outflow from a producing area to gross soil erosion in that area. Where one producing area receives sediment from an upstream area, such sediment transport is not used in calculating the downstream area's sediment delivery ratio. Where estimates of sediment outflow were not available, sediment delivery ratios for nearby producing areas were used. Thus, sediment delivery ratios estimate the percentage of the total amount of soil eroded in a producing area that reaches the point where streams flow out of that area.

In the RFF model, these ratios estimate the total amount of sediment delivered to streams from each county in the producing area. This methodology rests on two key assumptions: (1) that sediment discharge (and, by implication, gross soil erosion) occurs directly in proportion to the acreage of cropland and (2) that the sediment delivery ratio for the entire producing area is the same for each county within the producing area.

Operation of the Model.--Given estimates of industrial, municipal, household, and agricultural activities by county, the model inserts the residual pollution levels associated with these activities into the network. Point source residual pollution levels are inserted at nodal points; agricultural nonpoint source levels are distributed throughout the network.

The linkage in the model between the economic activities and the residual pollution levels depends on a large inventory of data on pollution generation and pollution control by industrial and nonindustrial sources. Many of these data show pollution levels at specific industrial facilities, although in most cases the necessary county detail has to be estimated from employment patterns and from information contained in a large number of industry studies. Many of these studies were undertaken in connection with the drafting of environmental regulations. Because there are over 3,000 counties, as many as 170 industrial sectors per county, nine pollutants (oxygen demanding loads, nitrogen, total phosphorus, dissolved solids, suspended solids, heavy metals, fecal coliform bacteria, oil and grease, and wastewater), and four assumed levels of residual control, this inventory contains over 18 million pieces of information.

Once estimates of the residual pollution levels are inserted into the network, the model estimates downstream concentrations. Conservative pollutants are merely diluted; nonconservative pollutants are subject to exponential decay. The parameters describing the rates of decay usually depend on both the concentration of the pollutant and the temperature of the water. Dissolved oxygen is estimated using a version of the Streeter-Phelps relationship.

These transport relationships require such data on stream and lake characteristics as flow, velocity, temperature, volume, and depth. While flow data are fairly readily available (except in estuaries), much of the other data had to be developed from unpublished records kept in regional USGS offices.

In many cases, missing data had to be estimated.

Strengths and Weaknesses of the Model.--The principal strength of the RFF National Water Network Model is that it provides estimates of water quality in specific bodies of water nationwide. It is thus indispensable in the analysis of comprehensive national policies affecting water quality. However, the simplifications necessary for its national coverage may not be adequate for the detailed analysis of specific situations. The model was never intended for microanalysis.

Although there are no standard measures of accuracy for these sorts of estimates, some indication of the performance of the model can be obtained by comparing "base year" (1972) concentration estimates with recorded observations taken at about the same time. About 10 percent of the network's nodal points correspond to official monitoring stations where actual measurements are made for one or more of the nine pollutants estimated in the system.

Although verification efforts have not been completed, certain preliminary conclusions can be drawn. The system appears to have a tendency to overestimate concentrations, partly because the relatively small number of nodal points in the system implies that loadings will be too heavy at single geographical points and partly because it is assumed that certain pollutants (such as dissolved solids) are conserved throughout the network (when in reality they are not totally conserved). However, the trend of concentration from one point to another seems to be estimated fairly well. A profile of biological oxygen demand concentration in the Ohio River illustrates these conclusions. The model apparently overestimates biological oxygen demands in the Pittsburgh area; overall, however, it seems to predict the general trend in pollution.

The profile also illustrates certain difficulties in making comparisons between the model's estimates and the monitoring data. The major difficulty is that the model predicts best and worst conditions in a particular year, while the monitoring data describe median conditions over a range of years. As a result, the flow conditions at a particular point may not be comparable between the measured data and the model. Thus, it is quite possible that in 1972 the biological oxygen demand reading in Pittsburgh actually approached the predicted 10 to 12 milligrams per liter range on the day with the lowest flow. Unfortunately, for many rivers--the Ohio included--actual daily readings are not available. Perhaps verification exercises will stimulate more data collection in waters that the model predicts will be polluted.

RFF is continually modifying the model is in order to improve its estimating ability. Soon, the data on economic activities will be updated to reflect the current Census. Also, sediment transport relationships will be introduced. This latter improvement will enable the model to estimate the concentrations of pesticides, toxic chemicals, and suspended sediment.

The 1980 RCA Yield/Soil Loss Simulator

The crop yield simulator was created by Paul Dyke and Linda Hagen of the National Resource Economics Division of the Economics, Statistics, and Cooperatives Service (ESCS). This simulator quantifies the relationship

between soil depth and crop yields. An understanding of this relationship is necessary in order to determine the impact of water and wind erosion on the inherent long term productivity of the soil. Many factors--for example, climate, soil texture, slope, irrigation, and soil tilth--influence this relationship. Therefore, any depth-yield relationship developed for use on a national basis must address these factors and treat them in a logically consistent manner for all regions. Consistent treatment was particularly important in this case because the Yield/Soil Loss Simulator was integrated into the National Agricultural Linear Programming Model, which simulates long term regional shifts in crop production.

Relationships among yields, fertilizer use, and management methods are not addressed in the simulator because these annual decisions were incorporated into other parts of the national model. The long term effects of conservation tillage and crop rotation, however, are addressed because these practices affect soil erosion and, therefore, soil depth.

Data Files.--The data used in the simulator come from three sources: Soil Conservation Service (SCS) soil surveys, SCS soil series, and ESCS county historical yield data.

- Soil surveys.--The National Resource Economics Division of ESCS compiled data from more than 1,100 published soil surveys (Fritchen and Hanson, 1979b). The information extracted from the soil surveys consists of the soil map unit name, the acreage of that map unit in the county, the yields of three to twelve major crops on each soil, soil slope, erosion phases, and soil classification. This data file contains about 450,000 records representing more than 70,000 unique types of soil in the United States. The soil survey file, however, did not include information on soil depth.

- Soil series.--Information on soil depth was extracted from more than 12,000 soil series recorded in the SCS Soils-5 data file (Young and McCormack, 1979). The Soils-5 file recorded the uneroded depth of three soil layers. The depth of the surface layer was then adjusted according to the erosion phase (slightly, moderately, or severely eroded) of the particular soil.

- Yield data--The soil surveys used were published during the period 1960 through 1978. The yields reported in those surveys, therefore, represented 19 years of changing technology and farming practices. In order to remove this discrepancy, 8 years (1969-77; 318,000 records) of county historical crop yield data (collected by the Statistics Division of ESCS) were statistically processed into technology-trend lines. From these lines, the estimated 1974 yields were recorded. Using these values and the map unit acreages as weights, the soil survey yields were adjusted to represent an average yield for each crop at the 1974 technology level (Fritchen and Hanson, 1979a). These adjusted yields were called normalized yields, but the process of adjustment may provide higher yields than might routinely be expected.

Data Enhancement.--These data files were processed through a series of computer programs in order to match codes, verify, reformat, and in general prepare a data file suitable for statistical processing. For example, the

soil name was processed to give the soil series, the soil texture, and the soil erosion phase. Soil series names in the two files were matched in order to get a single file containing soil depth, texture, slope, irrigation, classification, and normalized yield. State and county identification codes were matched with the county synonym file to add geographic identifiers such as water resource regions, producing areas, and major land resource areas (Dyke and Giardina, 1979; Dyke, 1979).

Equation Estimation.--The file was divided according to crops in the 18 geographic water resources regions in the conterminous United States. From this file, the 10 major crops used in the National Agricultural Linear Programming Model were selected. These crops are barley, corn, cotton, legume hay, nonlegume hay, oats, pasture, sorghum, soybeans, and wheat. A statistical equation was developed for each crop in each water resources region where the crop is grown. In several cases, not enough observations were available to quantify relationships, so regions were combined to increase the statistical reliability of the equations. The number of observations used in developing each equation ranged from 300 to more than 4,000 per crop per region.

The equation estimates a value of the dependent variable--normalized yields--by quantifying the impact on yield of the independent variables--soil texture, irrigation, thickness of the three soil horizons, slope, land capability subclass, and location. Once the statistical analysis is carried out, specific equations are analyzed, selected, and programmed into the 1980 RCA Yield/Soil Loss Simulator.

Applications of the Simulator.--The simulator can estimate the impact on irrigated and nonirrigated yields of changing soil depth for soils of varying slopes, texture, and land capability subclass, by crop by producing area. Erosion rates from the NRI were incorporated into the model and extrapolated over 50- and 100-year periods to estimate the change in yields that would occur if current erosion rates were to continue unabated. In many producing areas, the decrease in yield is as high as 34 percent on some land capability subclasses (IIe, IVe, and VIe) (Hagen and Dyke, 1979a).

An alternative analytic procedure is to remove 1 inch of topsoil at a time to determine the incremental effects on yield. This method has the theoretical advantage of removing the time element from the analysis. Again, as topsoil thickness decreases, yield decreases accordingly (Hagen and Dyke, 1979b; Hagen and Dyke, in process).

Data from the 1980 RCA Yield/Soil Loss Simulator are used in various forms throughout the RCA Appraisal, for example, in Potential Problem Area 1, Soil Resources (Chapter 3, section A). The simulator was designed, however, for incorporation into the CARD-USDA National Agricultural Linear Programming Model. Consequently, in the simulator yield depends only on soil characteristics. Fertilizer use, management practices, and other relevant factors are taken into account elsewhere in the linear programming model.

Introducing the effects of soil loss on yields significantly affected the results of the alternative linear programming model computer runs. In particular, as soil erosion lowered yields for certain erosive crops and

cropping practices, the "minimum cost LP model" would locate the more erosive crops on the less erodible soils and choose less erosive crop rotations. (The "minimum cost model" is the alternative that assumes that farmers will choose the least expensive conservation practices.) This was particularly true in the runs in which the total amount of soil erosion was restricted (that is, the model found it cheapest to maintain soil productivity over the 50-year period by using more intensive conservation rotations over the entire period). When erosion was reduced by 30 percent, interaction between the yield generator and the linear programming model resulted in solutions that required no significant increase in land base. Analyses of results from these computer runs are in preliminary stages. Detailed reports are forthcoming.

The most important and necessary extension of the Yield/Soil Loss Model is its forthcoming integration with soil moisture/water balance models now being developed. The soil characteristics used in the model affect soil-water relationships, which in turn have significant impacts on yields. Examples of such soil-water relationships include availability of soil moisture, available water capacity, extractable water content, permeability, runoff, drainage, infiltration, and the amounts, intensity, and timing of irrigation water.

Data observations from the soil survey were grouped by capability class and subclass. As soils become severely eroded, the subclass can change, for example, from IIIe to IVe or from IVe to VIe. Soil series names may also change as topsoil erodes because the texture of the underlying soil differs. Thus, there may be some inconsistency underlying the land class groupings as used in the model.

The Water Priority Model for RCA

The Economics, Statistics, and Cooperatives Service has developed a model to identify and rank aggregated subareas (ASA's) having critical water pollution problems. The rankings indicate where water pollutants affect a large number of people, where existing water pollution is severe, and where expenditures to correct water quality problems will yield the greatest returns.

In arriving at these rankings, the water priority model uses outputs from the other computer models used in RCA analyses. It uses the outputs from the Resources for the Future (RFF) model, which shows pollutant loadings. RFF model outputs were, in turn, determined from land use data provided by the National Agricultural Linear Programming Model.

The water priority model processes RFF model outputs with data on social and environmental factors discussed in Potential Problem Area 2, Water Quality (see chapter 3, section B). The social and environmental factors considered important for ranking the critical areas are:

- Density of population.--Potentially higher benefits can be realized from corrective actions in ASA's having large populations.

- Existing pollution problems.--Problems in water bodies where water quality standards are not being met will be addressed first in order to meet 1983 water quality goals.

- Cost of treatment.--For each ASA the conservation practices needed and the costs of those practices provide a means of evaluating cost effectiveness.

- Types of pollutants.--The major types of pollutants are assigned relative weights in order to emphasize the areas where pollution is considered most serious. The weights used in the priority model are: toxic substances, 4.0; organic wastes, 3.0; nutrients, 2.5; dissolved solids, 2.0; and sediment, 1.0.

The values for the pollutant categories are weighted as outlined above to develop a composite index and to provide a measure of the relative quality of the water in different areas. This index combines several factors: pollutant loadings, treatment costs, the intensity of chemical and fertilizer use, and pollution levels from the National Agricultural Linear Programming and RFF models. Values in the index show the relative importance of pollution problems in the ASA's.

Once the water quality model has ranked ASA's having critical water pollution problems, information on those priority areas can be used in the National Agricultural Linear Programming Model.

ACP Evaluation

A primary objective of the Agricultural Conservation Program (ACP) is to reduce soil loss on farmland. However, the program has lacked information and techniques for making reliable estimates of erosion rates and of results of practices. USDA has identified and quantified erosion problems and appropriate practices without benefit of sound estimates of need. The ACP evaluation was based on methodology designed to help overcome this deficiency.

Through agricultural research, enough basic data have been gathered on runoff and soil loss that a relatively simple technique to help plan and manage erosion control programs has become available. This predictive technique is the universal soil loss equation (see section A).

Procedure and Methodology.--An ACP evaluation team was established by Presidential directive. This team worked under the leadership of the Under Secretary of Agriculture for International Affairs and Commodity Programs, the Assistant Secretary for Natural Resources and Environment, and the Director of Economics, Policy Analysis and Budget. It collected information from a sample of 171 counties, which comprise the ASCS work measurement system. These counties are shown in table 7B-2.

All applicable ACP practices performed in the sample counties from 1975 through 1978 were included in the study. Overall, 60,444 cases were included. Each case represented an ACP practice carried out by farmers on their land under federal cost sharing.

In each case, USDA collected information on farm size, farm type, the kind of arrangement (long term or annual agreements) under which payment was made, practice costs, percentage levels at which the sample practices were cost shared, acreage treated or served by the practice, or number of structures

involved. USDA also obtained information for use in estimating soil loss before and after the application of conservation measures or practices. These estimates were based on the universal soil loss equation.

For the four water conservation practices included in the study, Soil Conservation Service technicians estimated the number of acre feet of water used before and after installation of the practice. The difference indicated the degree of effectiveness of the practice.

The ACP sample cases to be evaluated included 1,261 forestry cases. Because of time and personnel limitations, 180 cases were selected for intensive field review by choosing each seventh case from the total. All 180 cases were not examined in the field. A few of the cases were Forestry Incentives Program, not ACP, cases. Work had not been completed and no payment had been made on a few cases. Because a disproportionately high number of cases were in three counties in Michigan and in three in Wisconsin, not all of the cases selected in those areas were reviewed. The 145 forestry cases that were reviewed were located in 54 counties.

The practices in all 145 cases were implemented in 1975, 1976, and 1977. Because of the time since implementation, USDA could thoroughly examine the results. It determined, for example, that 10 percent of the tree planting cases that fail do so within the first year after planting. Other studies have shown that about 85 percent of the ACP and Soil Bank plantations are still in place 10 to 18 years after they were established (Kurtz, 1978). Examination of the forestry practices, after they had been established for a year or more, provided an opportunity to describe the response of grasses, forbs, and shrubs planted for wildlife habitat or to control erosion.

USDA conducted the overall 1978 ACP program evaluation primarily to determine the program's effectiveness in reducing soil erosion or conserving water. In places the forestry practices were implemented to provide additional wildlife cover or for esthetics, windbreaks, recreation, and other uses as well as to reduce erosion and maintain watershed values. In those areas, USDA evaluated the results in relation to the stated objectives.

A Forest Service evaluation task force compiled the results of the field forms. Wildlife biologists, hydrologists, and soil scientists helped design the forms, implement the survey, and evaluate the results.

Impact Regions.--The data for the ACP sample cases were compiled by geographic impact regions (fig. 7B-5). Regional data helped USDA better relate the findings of the evaluation to specific regional characteristics and conservation problems. Regions were delineated on the basis of aggregation of major land resource areas (Austin, 1972); factors such as similarity of soils, topography, climate, and agricultural commodity production; cropping patterns; and soil and water conservation problems.

Table 7B-2.--Counties in the ASCS work measurement system

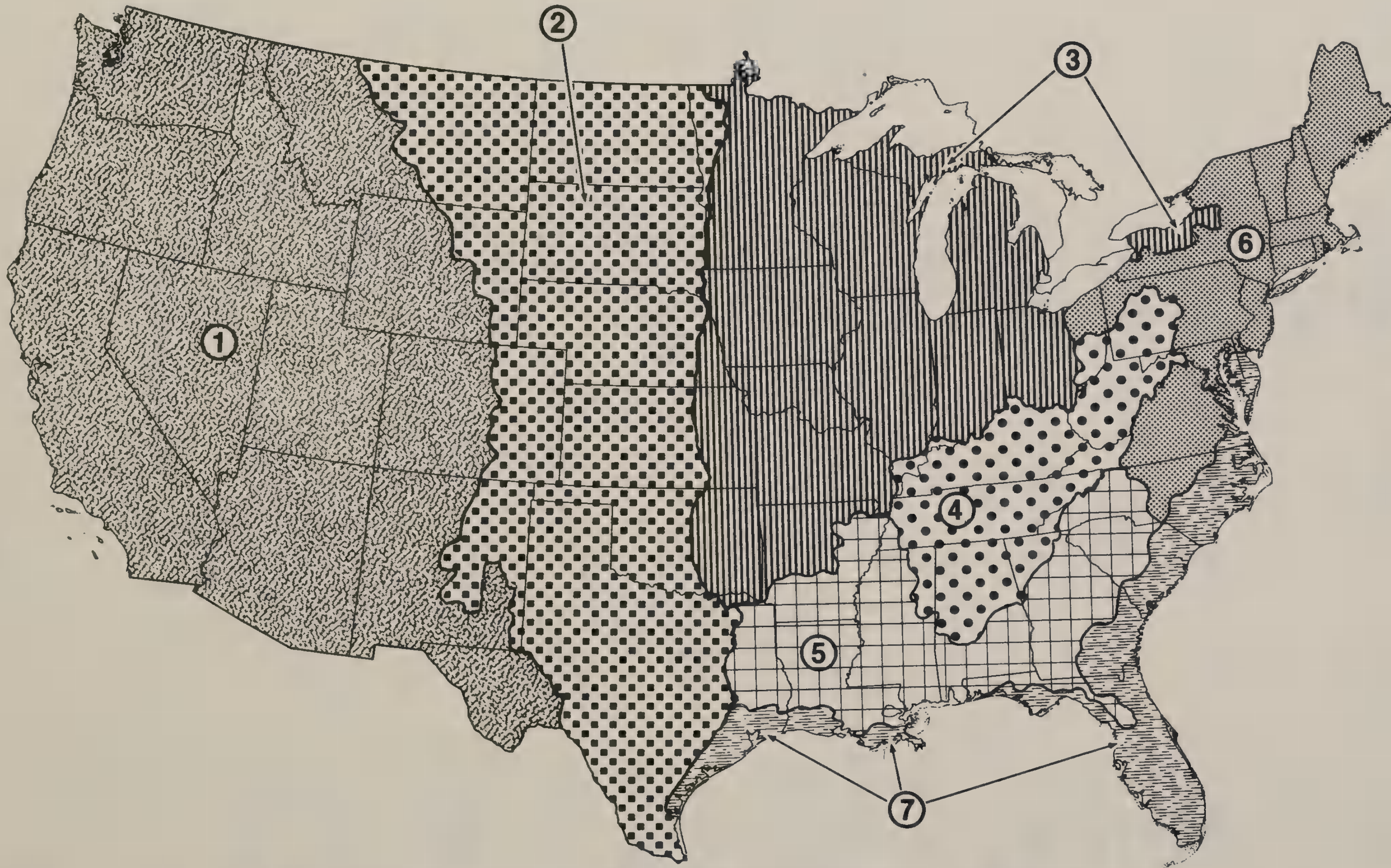
State	Counties
Alabama	Geneva Jackson Marion Tuscaloosa
Arizona	Pima Santa Cruz
Arkansas	Arkansas Greene Izard Lee
California	Butte Fresno Glenn Solano
Colorado	Gunnison Kiowa Montrose Otero
Delaware	Sussex
Florida	Alachua Lafayette Marion
Georgia	Clay Colquitt Elbert Emanuel Heard Jeff Davis Laurens Quitman Troup
Idaho	Kootenai Washington
Illinois	Clinton De Witt Hancock Kendall Washington
Indiana	Cass Fayette Gibson Jennings La Porte Lawrence
Iowa	Appanoose Cass Cedar Dallas Scott
Kansas	Harvey Lincoln Rice Sheridan Wichita
Kentucky	Ballard Edmonson McCreary Mason Montgomery Perry Webster
Louisiana	Iberia Parish Richland Parish West Carroll Parish
Maine	Oxford
Maryland	Talbot
Massachusetts	Franklin Hampshire
Michigan	Cheboygan Isabella Oceana Presque Isle Van Buren

Table 7B-2.--Counties in the ASC work measurement system--Continued

State	Counties	State	Counties
Minnesota------	Goodhue	North Carolina-	Columbus
	Hubbard		Johnston
	Isanti		Lenoir
	Lac qui Parle		Nash
	Marshall		Vance
Mississippi----	Amite	North Dakota---	Burleigh
	Lauderdale		Montrail
	Marshall		Traill
	Sunflower		
	Winston	Ohio-----------	Allen
			Highland
Missouri-------	Audrain		Trumbull
	Daviess		Wayne
	Laclede		
	Lincoln	Oklahoma-------	Garfield
	Pemiscot		Garvin
	Pettis		Haskell
			Kiowa
Montana--------	Gallatin		
	Judith Basin	Oregon---------	Clackamas
	Liberty		Jefferson
			Multnomah
Nebraska-------	Douglas		
	Garden	Pennsylvania---	Clarion
	Red Willow		Huntingdon
	Sherman		Lycoming
	Thayer		
		South Carolina-	Fairfield
Nevada---------	Elko		Greenville
	Eureka		Horry
	White Pine		
		South Dakota---	Edmunds
New Hampshire--	Cheshire		Hamlin
			Meade
New Jersey-----	Morris		
	Sussex	Tennessee------	Bledsoe
	Warren		Cocke
			Smith
New Mexico-----	Harding		Sumner
	Sierra		Tipton
New York-------	Genesee		
	Montgomery		

Table 7B-2.--Counties in the ASC work measurement system--Continued

State	Counties	State	Counties
Texas----------	Dawson	Virginia-------	Bedford
	Donley		Cumberland
	El Paso		Grayson
	Harris		Halifax
	King		Lunenburg
	Knox		
	McLennan	Washington----	Grant
	Nacogdoches		Stevens
	Ochiltree		
	Pecos	West Virginia--	Lewis
	Van Zandt		Preston
	Williamson		
	Wise	Wisconsin------	Jefferson
			Price
Utah-----------	Washington		Vernon
			Waupaca
Vermont--------	Chittenden		
		Wyoming--------	Goshen



Region 1	Western United States Including Desert and Mountain Range, Forest and the Subtropical Truck, Fruit and Specialty Crop Region of the Western Coast.	**Region 4**	Appalachian Farming and Forest Region.
Region 2	Great Plains.	**Region 5**	Southern Coastal Plain or Piedmont.
Region 3	Midwest — Corn Belt, Lake States, Fruit, Truck, Dairy, Forest, and Livestock Region.	**Region 6**	New England and Northern Atlantic Slope, Truck, Fruit and Poultry Region.
		Region 7	Atlantic and Gulf Coast Lowland Forest Subtropical Fruit, Truck and Range Region.

Figure 7B-5.--Geographic impact regions for ACP evaluation.

References

Agriculture and Resource Inventories Through Aerospace Remote Sensing. 1979. Soil moisture implementation plan. National Aeronautics and Space Administration, U.S. Department of Agriculture, U.S. Department of the Interior, Agency for International Development, and National Oceanographic and Atmospheric Administration.

Austin, Morris E. 1972. Land resource regions and major land resource areas of the United States (excluding Alaska and Hawaii). U.S. Dep. Agric., Agric. Handb. No. 296, 82 pp. (Revision in press)

Dyke, Paul, and Diane Giardina. 1979. County identification codes and cross reference tables. Economics, Statistics, and Cooperatives Service, National Resource Economics Division. Working Paper No. 67, January 1979.

Dyke, Paul. 1979. County identification file. Data Base No. 537, LAWREMS Directory, Version 1. Economics, Statistics, and Cooperatives Service, National Resource Economics Division. Resource Systems, January 1979.

Environmental Protection Agency. 1977. National water quality inventory: 1977 Report to Congress.

Fritchen, John F., and Marlin Hanson. 1979a. County historical crop data: 1969-76. Data Base No. 542, LAWREMS Directory, Version 1. Economics, Statistics, and Cooperatives Service, National Resource Economics Division. Resource Systems, January 1979.

Fritchen, John F., and Marlin Hanson. 1979b. County soils and yields data. Data Base No. 618, LAWREMS Directory, Version 1. Economics, Statistics, and Cooperatives Service, National Resource Economics Division. Resource Systems, January 1979.

Hagen, Linda L., and Paul Dyke. 1979a. An index of yield changes due to soil loss: Maps for selected crops. Economics, Statistics, and Cooperatives Service, National Resource Economics Division. Resource Systems, Preliminary Report. (Draft).

Hagen, Linda L., and Paul Dyke. 1979b. Incremental corn yields as a function of soil depth. Economics, Statistics, and Cooperatives Service, National Resource Economics Division. Resource Systems, Preliminary Report. (Draft).

Hagen, Linda L., and Paul Dyke. (In process.) Handbook of yield-soil loss relationships. Economics, Statistics, and Cooperatives Service, in association with Soil Conservation Service.

Kurtz, William B. 1978. Analysis of the retention and condition of Agricultural Conservation program tree planting practices. U.S. Dep. Agric., For. Serv. Rocky Mt. For. and Range Exp. Stn. and Univ. Mo. 40 pp.

Shaw, Samuel P., and C. Gordon Fredine. 1956. Wetlands of the United States. U.S. Dep. Int., Fish Wildl. Serv. Circ. 39., 67 pp.

Skidmore, E.L., and N.P. Woodruff. 1968. Wind erosion forces in the United States and their use in predicting soil loss. U.S. Dep. Agric., Agric. Handb. No. 346, 42 pp. (In cooperation with Kansas Agric. Exp. Stn.).

United States Department of Agriculture, Soil Conservation Service. 1958. 1958 Conservation needs inventory.

United States Department of Agriculture, Soil Conservation Service. 1967. 1967 Conservation needs inventory.

United States Department of Agriculture, Science and Education Administration, in cooperation with Purdue Agricultural Experiment Station. 1978a. Predicting rainfall erosion losses: A guide to conservation planning. U.S. Dep. Agric. Handb. No. 537, 58 pp.

United States Department of Agriculture, Soil Conservation Service. 1978b. 1977 National resource inventories.

United States Water Resources Council. 1978. The Nation's water resources, 1975-2000. Second Natl. Water Assess.

Wade, James, and Earl O. Heady. 1976. A national model of sediment and water quality: Various impacts on American agriculture. Center for Agricultural and Rural Development, CARD Rep. No. 67.

Young, Keith, and D.A. McCormack. 1979. Soil survey interpretations. (Soils-5 File). Data Base No. 598, LAWREMS Directory, Version 1. January 1979.

APPENDIX

Glossary

Aggregated subarea (ASA). The Water Resources Council (WRC) breaks down the United States into water resources regions and subregions. Water resources regions are hydrologic areas that contain either the drainage area of a major river or the combined drainage areas of a series of rivers. A subregion is an area drained by a river system, a reach of a river and its tributaries in that reach, a closed basin or basins, or a group of streams forming a coastal drainage area. For collection of socioeconomic data, WRC adjusts the boundaries of these subregions along county lines to form subareas. Groups of these subareas are called aggregated subareas (ASA's). One or more ASA's, in turn, form each of the WRC regions.

Animal unit month (AUM). A measure of forage or feed required to maintain one animal unit--one cow, one horse, one mule, five sheep, five swine, or six goats--for a period of 30 days.

Best management practices (BMP's). An Environmental Protection Agency (EPA) term generally used in local water quality plans. A BMP is a practice or combination of practices that a state or designated areawide planning agency considers the most effective and practicable means of controlling the amount of nonpoint source pollution to meet water quality goals.

Biomass. (1) The total amount of living material in a particular habitat or area. (2) An expression of the total weight of a given population of organisms.

Conservation tillage. A form of mulch tillage that retains a protective amount of residue mulch on the surface throughout the year. (Some conservation tillage methods are: minimum tillage, no till, reduced tillage, stubble-mulch tillage, chisel planting, and till planting.)

Consumptive use. That part of water which is evaporated, transpired, incorporated into products and crops, consumed by humans and livestock, or otherwise removed from the immediate water supply.

Contour farming. Plowing, planting, cultivating, and harvesting on the contour of the land.

Cover crop. A close-growing crop planted primarily to protect and improve the soil. Farmers grow cover crops on fields between periods of regular crop production and around trees and vines in orchards and vineyards.

Critical average month. That month of average flow when the difference between available streamflow and water requirements is greatest (when the excess water is the least or when the shortage is the most of any month during the year).

Cropland. Land used primarily to produce cultivated crops, close-growing crops, and fruits and nuts.

Crop residue. The part of a plant or crop left in the field after harvest.

Current normalized price. The price of a commodity adjusted to reduce the influence of short-term fluctuations, such as abnormal weather, insect infestations, and sudden changes in demand.

Discount rate. A factor used to determine the current value of money that is to be paid or received in the future. The discount rate is based on a) the rate of return (the interest rate paid on the money) and b) the length of time under consideration.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and through such processes as gravitational creep.

Eutrophication. A process through which a body of water ages. Nourished aquatic plants--often algae--in waters enriched with nutrients and organic matter cause the water body to become shallower and deplete oxygen supplies seasonally.

Federal forest land. Land under federal ownership that is at least 10 percent stocked by forest trees of any size, and land that has lost its tree cover but has not been developed for nonforest uses.

Federal land. All land and small areas of water owned and managed by federal agencies, for example, national forests and parks, military reservations, public domain lands, and national grasslands.

Field windbreaks. A strip or belt of trees or shrubs established in or adjacent to a field to reduce soil blowing, control snow deposition, conserve moisture, protect crops and orchards, provide shelter for livestock and wildlife, or increase the natural beauty of an area.

Flood plain. Nearly level land that is situated on either side of a channel and that is subject to overflow.

Flood prone areas. Areas adjoining rivers, streams, watercourses, bays, lakes, alluvial plains, or other areas that have been intermittently flooded in the past or that can be expected to be flooded in the future. Areas subject to inundation by a flood having an average recurrence interval of once in 100 years, or a 1 percent chance of occurrence in any given year.

Forest stocking. The degree of occupancy of land by trees, measured by basal area and/or the number of trees on a stand by size or age and spacing, compared to the basal area and/or number of trees required to fully utilize the growth potential of the land.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. It conducts surface water away from cropland.

Ground water mining. An overdraft that occurs when water is withdrawn from the ground at a rate greater than the long-term rate of recharge.

Heavy metals. Those metals in wastes which, when they exceed certain amounts, can be toxic to humans, animals, or plants (cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc).

Hydraulic head. The height of the free surface of fluid above any point in a hydraulic system; a measure of the pressure of force exerted by the fluid.

Hydrologic soil group. A grouping of soils based on the runoff-producing characteristics of the soils.

Income elasticity. The arithmetical relationship between the percentage change in the quantity of a commodity bought and the percentage change in personal disposable income.

Industrial discharge. The liquid wastes from industrial processes, as distinct from domestic wastes.

Instream flow requirements. The amount of flow necessary to provide for the combined instream uses of water for fish, wildlife, recreation, navigation, hydropower, waste assimilation, and downstream conveyance.

Land capability classes and subclasses. The quality of soil resources for agricultural use is commonly expressed as land capability classes and subclasses, which show, in a general way, the suitability of soils for most kinds of field crops. Soils are grouped according to their limitations when they are used for field crops, the risk of damage when they are used, and the way they respond to treatment.

Capability classes, the broadest groups, are designated by Roman numberals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants.

Class III soils have severe limitations that reduce the choice of plants.

Class IV soils have very severe limitations that reduce the choice of plants.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and landforms have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class; they are designated by adding a small letter, "e," "w," "s," or "c," to the class numeral, for

example, IIe. The letter "e" shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; "w" shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); "s" shows that the soil is limited mainly because it is shallow, droughty, or stony; and "c," used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

Lower quartile summer flow. The U.S. Geological Survey describes streamflow by dividing the range of flow into quartiles. Thus, the flow between the upper and lower quartiles is considered normal flow. The lower quartile is that flow, usually occurring during the summer, which is considered the low flow, or below 25 percent of the total flow.

Management practices. Land treatment and cultural activities other than structural practices designed to protect and improve soil, plant, or animal resources.

Modified central case. Projections of flood damages that represent the most probable results of future flooding. This case assumes that flood plain regulations will be implemented at a rate faster than the current rate, but not up to the maximum practical level. It also assumes that structural measures will be installed at a slower rate than in the recent past.

Monoculture. Raising crops of a single plant variety, cultivated as well as natural.

Mulch. A natural or artificial layer of plant residue or other material on the soil surface.

Mulch tillage. A conservation tillage system that primarily uses subsurface tillage equipment designed to leave crop residue on the surface to prevent erosion.

Municipal discharge. Waste water derived principally from such sources as dwellings, business buildings, and institutions.

Native pasture. Areas where the natural potential plant community is forest, but the land is used and managed mainly to produce native grasses for forage.

Nonfederal forest land. Private, state, and municipal lands under at least a 25 percent tree canopy cover or at least 10 percent stocked with forest trees of any size, including land once forested that will be naturally or artificially reforested. It does not include transition zones between heavily forested and nonforested land that can also be defined as rangeland, nor does it include forested areas that can be defined as urban and built-up land.

Nonfederal land. All land and associated small water bodies owned by state and local governments, individuals, corporations, and other nonfederal entities.

Nonpoint source pollution. Pollution (runoff from urban, agricultural, forested, and mining areas) which is usually not controllable through existing technology for meeting effluent guidelines. It is generally best

controlled through land use practices or best management practices (BMP's). For the most part, nonpoint source pollution is manmade. Natural or background sources of pollution are not covered under this definition.

Overdrafting. The withdrawal of ground water at a rate greater than the long-term rate of recharge.

Oxygen demanding wastes. Wastes that consume oxygen in the biochemical oxidation of organic matter.

Pastureland. Land used primarily to produce domesticated forage plants for livestock. This land does not include rotation pasture or cropland under winter cover crops.

Phreatophyte. A plant dependent on ground water as opposed to soil moisture (for example, willow, cottonwood, greasewood, and saltcedar).

Planimetering. The measuring of the area of any plane surface by passing a tracer around the boundary line.

Plot years. A term used to express the number of erosion study plots and the years those plots were studied.

Point source pollution. Pollution from any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft. This term does not include return flows from irrigated agriculture.

Prime farmland. Land that is best suited to producing food, feed, forage, fiber, and oilseed crops and is available for those uses. It can be cropland, pastureland, rangeland, forest land, or other land. It has the soil quality, growing season, and moisture needed to economically produce sustained high yields of crops if managed according to acceptable farm practices. Prime farmland produces the highest yields with minimal expenditure of energy and economic resources and does so with the least damage to the environment.

Producing area. A geographic breakdown of the conterminous United States based on the 99 aggregated subareas (ASA's) (see aggregated subarea). There are 105 producing areas because 6 ASA's have two different agricultural patterns. Producing areas are used in the CARD-USDA National Agricultural Linear Programing Model at Iowa State University.

Range condition. The present composition of the plant community on a range site as it compares to the potential natural plant community for that site. Range condition is expressed as excellent, good, fair, or poor, depending on how much the present plant community has departed from the potential.

Rangeland. Land on which the natural potential (climax) plant cover is principally native grasses, grasslike plants, forbs, and shrubs. It includes natural grasslands, savannas, certain shrub and forb lands, most deserts, tundra, alpine communities, coastal marshlands, and wet meadows. It also includes lands that are revegetated naturally or artificially and are managed like native vegetation. Except for brush control, rangeland is managed

primarily by regulating grazing and protecting the plant cover. It is not cultivated, drained, irrigated, or mechanically harvested.

Rill erosion. An erosion process in which surface runoff forms numerous small channels a few inches deep in the soil. Rill erosion occurs mainly on recently cultivated soils.

Section 208. The section of the Federal Water Pollution Control Act (P.L. 92-500), as amended by Section 35 of P.L. 95-217, which provides for federal grants to develop plans for achieving national water quality goals.

Sediment delivery ratio. The ratio of sediment yield to gross erosion expressed as a percentage.

Shadow price. The total price or marginal cost of producing the last unit of a specific commodity.

Sheet erosion. The removal of a fairly uniform layer of soil from the land surface by rainfall and surface runoff.

Silviculture. The cultivation of forest crops according to a knowledge of silvics. The theory and practice of controlling the establishment, composition, and growth of forest.

Soil map unit. A collection of areas defined in terms of soils or miscellaneous areas, or both. Each map unit differs in some respect from all others in a soil survey area and is identified on a soil map.

Stream accounting unit. A measure of water quality using characteristics such as fecal coliform bacteria, inorganic nitrogen, and organic nitrogen.

Stripcropping. Growing crops in a systematic arrangement of strips or bands that serve as barriers to wind and water erosion.

Structural practices. Soil and water conservation practices that involve designed facilities, devices, or features that are constructed or manufactured.

Stubble-mulching. Leaving the stubble of crops or crop residue in place on the land as a surface cover during fallow and the growing of a succeeding crop.

Terrace. (1) An embankment or ridge constructed across sloping soils on the contour or at a right angle to the contour. The terrace intercepts surface runoff so that it can soak into the soil or flow slowly to a prepared outlet. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod. (2) A level, usually narrow plain bordering a river, lake, or sea. Rivers sometimes are bordered by terraces at different levels.

Thermal pollution. Degradation of water by the introduction of excess heat.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, that occur in extremely small amounts in soils.

Urban and built-up areas. Cities, villages, other built-up areas of more than 10 acres, industrial sites, railroad yards, cemeteries, airports, golf courses, shooting ranges, institutional and public administration sites, and similar areas.

Water resources regions and subregions. See aggregated subarea (ASA).

Water table. The upper surface of ground water, or that level below which the soil is saturated with water; the focus of points in soil water at which the hydraulic pressure is equal to atmospheric pressure.

Water-use efficiency. The minimum amount of water used per unit of production.

Water year. A continuous 12-month period from October 1 to September 30.

Wind erosion. The detachment and transportation of soil by wind.

Wind erosion equation. A mathematical equation used for estimating the quantity of wind erosion.

Wind erosion group. A group of soils with similar wind erodibility hazard.

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